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Energy Efficiency Potential and Goals Study for 2015 and Beyond

Stage 1 Final Report

Prepared for:
California Public Utilities Commission

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Executive Summary

Introduction

Navigant Consulting, Inc. along with its partners Tierra Resources Consultants LLC, DNV GL, ASWB Engineering, RedHorse Corp, and Opinion Dynamics (collectively known as "the Navigant team") developed this study ("2015 and Beyond Potential and Goals Study") to analyze energy and demand savings potential in the service territories of four of California's investor-owned utilities (IOUs) during the post 2015 energy efficiency (EE) portfolio planning cycle. This report includes results for Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas (SCG). A key component of the 2015 Potential and Goals Study (2015 Study) is the Potential and Goals Model (PG Model), which provides a single platform in which to conduct robust quantitative scenario analysis that reflects the complex interactions among various inputs and Policy Drivers.

The 2015 Study is the third consecutive potential study conducted by the Navigant team on behalf of the California Public Utilities Commission (CPUC). Navigant conducted the 2011[1] study which informed the 2013-14 IOU program goals and the 2013 Study[2] which was used to inform the 2015 goals for California IOUs. The model developed in the 2013 Study serves as the methodological basis for this study. As such, the 2015 study is considered an "update study" relative to the 2013 Study.

The 2015 Potential and Goals Study supports four related efforts:

1. Inform the CPUC as it proceeds to adopt goals and targets, providing guidance for the next IOU energy efficiency portfolios. The potential model is a framework that facilitates the stakeholder process. The model helps build consensus for goals by soliciting agreement on inputs, methods, and model results.
2. Guide the IOUs in portfolio planning and the state' principal energy agencies in forecasting for procurement, including the planning efforts of the CPUC, California Energy Commission (CEC), and California Independent System Operator (CAISO). Although the model cannot be the sole source of data for IOU program planning activities, it can provide critical guidance for the IOUs as they develop their plans for the 2016 and beyond portfolio planning period. The study is also providing California's principal energy agencies with the tools and resources necessary to develop outputs in a manner that is most appropriate for their planning and procurement needs.
3. Inform strategic contributions to greenhouse gas reduction targets. As the rules and impacts of Assembly Bill (AB) 32 are gaining traction, the model must account for Greenhouse Gas (GHG) savings estimates. This will provide an opportunity to understand how extensively IOU programs and energy efficiency can help meet AB32 goals. Navigant will work with the CPUC and stakeholders to develop stretch GHG reduction scenarios.

[1] Navigant. *Analysis to Update Energy Efficiency Potential, Goals, and Targets for 2013 and Beyond - Track 1.* May 2012.
[2] Navigant. *2013 California Energy Efficiency Potential and Goals Study*. February 2014.

4. Develop metrics for the CPUC's Energy Efficiency Strategic Plan update.[3] The Plan identifies a number of strategies that move beyond current approaches for energy efficiency resource deployment and lays the groundwork for their implementation. The 2015 Study is expected to inform, as well as be informed by the Plan, by helping to provide metrics, including projections of additional energy savings estimates, for the 2015 Strategic Plan Update Goals. This may include aligning the potential model with strategic plan initiatives, identifying appropriate metrics, characterizing the baseline, developing scenarios, and creating a tracking mechanism.

CPUC policy making informed and directed this study, as outlined in Rulemaking (R.) 09-11-014 and most recently by Decision (D.) 12-05-015, which provided guidance on the 2013-2014 energy efficiency portfolios. D.14-10-046 (Phase I of R.13-11-005) adopted energy efficiency savings goals for 2015 and Phase II of the proceeding will adopt goals for a three year period starting in 2016.[4] The study period spans from 2016-2024 based on the direction provided by CPUC and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of energy efficiency savings in publicly owned utility service territories is not part of the scope of this effort.

The Navigant team and the CPUC have conducted outreach to stakeholders in the development of this model. The comments and questions raised during these meetings have informed the development of the PG Model and the study.

Scope of this Study

The four primary uses of the 2015 and Beyond Potential Study correspond to the four distinct tasks that will be used throughout the project:

- **Task 1 Potential and Goals Study Update.** This task will **i**nform the CPUC as it proceeds to adopt goals for future IOU energy efficiency portfolios.
- **Task 2: Additional Achievable Energy Efficiency (AAEE) Savings Forecast.** This task will develop savings forecasts for use by CPUC, CEC, and CAISO in long term planning exercises.
- **Task 3: Energy Efficiency Targets for Greenhouse Gas Reductions.** This task will quantify how extensively IOU programs and energy efficiency can help meet AB32 goals.
- **Task 4: Metrics to Support the Strategic Plan Update.** This task will help provide metrics, including projections of additional energy savings estimates, for the 2015 Strategic Plan Update Goals.

This report represents the first of multiple updates to the potential study that will occur through 2018. This report focuses on Task 1: Potential and Goals Study Update. Specifically, this report represents the first stage of Task 1 updates (Stage 1). The CPUC and Navigant worked together to determine the appropriate scope of Stage 1 updates given the regulatory timeline for setting 2016 and beyond goals. Stage 1 of Task 1 is primarily a data update to the PG model to inform 2016 and beyond goals; it is the sole topic of this report. The scope of Stage 1 was to:

[3] More information on the Plan can be found at: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/eesp/
[4] Note that the 2016-2018 period is tentative and will ultimately be determined in Phase II of R.13-11-005.

- » Maintain the 2013 PG Model methodology, infrastructure, architecture, and types of output (the 2013 PG model methodology is documented in detail in the 2013 Study report[5]);
- » Correct minor issues where the 2013 PG model methodology is not aligned with current CPUC policy; and
- » Rely on new secondary data sources to update the PG model with the latest available information to better inform the 2016 and beyond goal setting process.

The majority of the effort undertaken by the team on Stage 1 was to review and incorporate the latest available data into the study. The CPUC provided the following high level direction to Navigant throughout the data update process:

- » Database for Energy Efficient Resources (DEER) data must be incorporated for high impact measures including DEER2014 Update and DEER2015 Update.[6]
- » 2010-12 Evaluation, Measurement, and Verification (EM&V) impact studies should further update DEER data for residential and commercial measures.
- » 2010-12 EM&V evaluations should be used to inform updates to Codes and Standards (C&S) analysis, behavior program analysis, and financing analysis.
- » The latest California appliance saturation survey studies should be relied upon for key market data.
- » In regards to IOU workpapers, the Navigant team should only rely upon those reports that went through a rigorous CPUC review process (however, un-reviewed workpapers could be used to characterize emerging technologies).
- » In regards to Industry Standard Practice (ISP) studies, the Navigant team should only rely upon those that are CPUC vetted and approved.

Given the short timeline of Stage 1, the various data update tasks were prioritized by the team along with CPUC input. Table ES-1 lists the Stage 1 key data update activities along with their assigned priority. The priority indicates the relative level of effort allocated to each update activity; high priority items obtained more attention and resources than low priority items.

[5] Navigant. *2013 California Energy Efficiency Potential and Goals Study*. February 2014. The report is available at http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm.

[6] The full DEER2016 cannot be incorporated into Stage 1 due to the timeline of the DEER2016 release relative to the timeline of Stage 1. However, the Navigant team did coordinate with the DEER team to best align the study to any new DEER changes and made some high priority adjustments to the potential study in responses based on a draft of DEER2016.

Table ES-1: Stage 1 Data Update Priorities

Key Data Update Activity.	Stage 1 Priority
Update Residential and Commercial measures with the following data sources: DEER, 10-12 EM&V studies, the Measure Cost Study, and saturation studies.	High
Update C&S savings analysis using the 2010-12 impact evaluation study, update methodology to match CPUC policy.	High
Update Agricultural, Industrial, Mining, and Street-Lighting to incorporate the latest Industry Standard Practice studies.	High
Incorporate the latest non-measure inputs regarding retail rates, building stocks, avoided costs, and utility program costs.	High
Update Whole Building Energy Efficiency data using 2010-12 EM&V data, DEER data, CEC building code data, and other available studies.	Medium
Update Emerging Technologies data assumptions, specifically review LED assumptions with regards to the California Lighting Quality Standards.	Medium
Provide the ability to view measure level results from the model.	Medium
Update Behavior and Conservation analysis with latest EM&V and utility data and coordinate with the ongoing CPUC behavior studies.	Low
Update Financing analysis with latest EM&V data and coordinate with the ongoing CPUC financing studies.	Low

Source: Navigant team discussions with CPUC Staff

Sources of Potential

Consistent with the 2013 Study, the 2015 Study examines the potential from the following:

- Residential and Commercial rebated measures
- Agriculture, Industrial, and Mining rebated measures
- Street Lighting measures
- Residential and Commercial behavior programs (home energy reports and building operator certification/training)
- Codes and Standards
- "Emerging Technologies" for the Residential, Commercial, and Street Lighting sectors
- Whole building initiatives (existing building renovation and new construction for the Residential and Commercial sector)
- Low Income programs
- Incremental savings due to energy efficiency financing

Consistent with the 2013 Study, the 2015 Study forecasts energy efficiency potential at three levels for rebate programs:

1. **Technical Potential**: Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve energy efficiency were taken, including retrofit measures, replace-on-burnout measures, and new construction measures. Technical potential represents the immediate replacement of applicable equipment-based technologies regardless of the remaining useful life of the existing measure. Consistent with industry best practices, technical potential does not and is not meant to account for equipment stock turnover.
2. **Economic Potential**: Using the results of the technical potential analysis, the economic potential is calculated as the total energy efficiency potential available when limited to only cost effective measures.[7] All components of economic potential are a subset of technical potential. Similar to technical potential, economic potential does not account for equipment stock turnover.
3. **Market Potential**: The final output of the potential study is a market potential analysis, which calculates the energy efficiency savings that could be expected in response to specific levels of incentives and assumptions about policies, market influences, and barriers. All components of market potential are a subset of economic potential. Some studies also refer to this as "achievable potential." Market potential is used to inform the utilities' energy efficiency goals, as determined by the CPUC.

The market potential reported in this study is the incremental market potential. The incremental potential represents the annual energy and demand savings achieved by the set of programs and measures in the first year that the measure is implemented. It does not consider the additional savings that the measure will produce over the life of the equipment. A view of incremental savings is necessary in order to understand what additional savings an individual year of energy efficiency programs will produce. This has historically been the basis for IOU program goals.

A large number of variables drive the calculation of market potential. These include assumptions about the manner in which efficient products and services are marketed and delivered, the level of customer awareness of energy efficiency, and customer willingness to install efficient equipment or operate equipment in ways that are more efficient. The Navigant team used the best available current market knowledge and followed these guidelines in developing the recommended market potential:

1. Provide a view of market potential where data sources and calculation methods are transparent and clearly documented.
2. Avoid assumptions and model design decision that would establish goals and targets that are aspirational, but for which the technologies or market mechanisms to attain these goals may not yet be clearly defined.

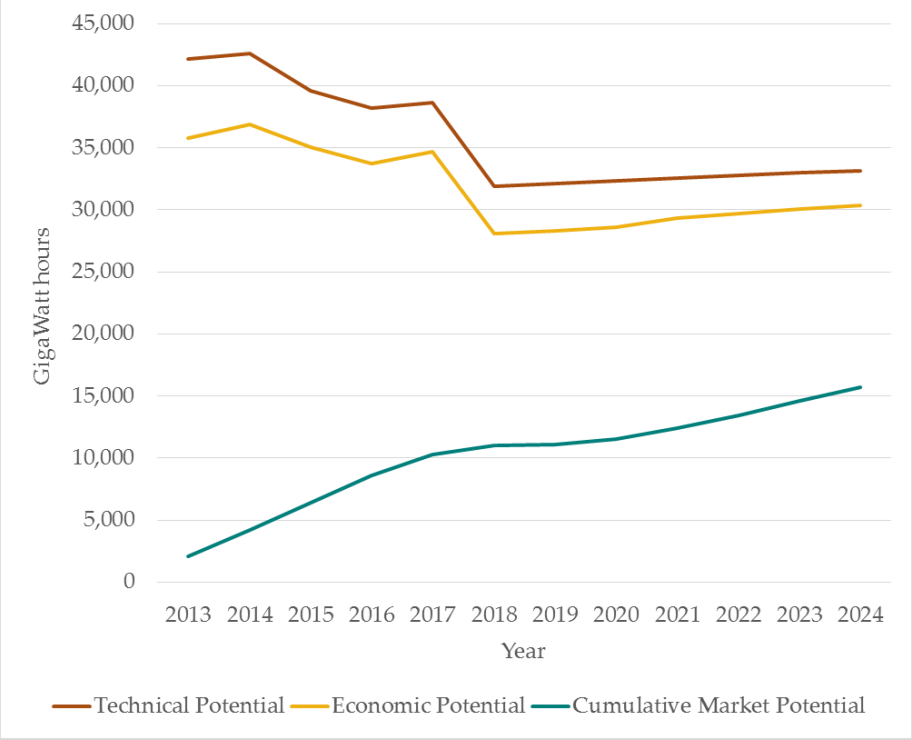
[7] The default assumption for this study includes all non-emerging technologies with a total resource cost (TRC) test of 0.85 or greater; emerging technologies are included if they meet a TRC of 0.5 in a given year and also achieve the TRC for non-emerging technologies (0.85) within ten years of market introduction. The model includes savings from measure bundles commonly adopted for low income programs; low income programs generally have a TRC less than 0.85 and are not required to be cost effective. These measure bundles are thus included for the purposes of calculating economic potential.

With these precepts in mind, the Navigant team considers that the market potential presented in this study is a viable basis for energy efficiency forecasting to which load forecasters, system planners, and resource procurement specialists could agree. However, this study may not capture the upper bound on the total amount of energy efficiency that can be achieved. There may be additional energy savings to capture, particularly from systems efficiency and behavior change, which could not be reliably quantified based on past EM&V results available at the time of this study.

Results

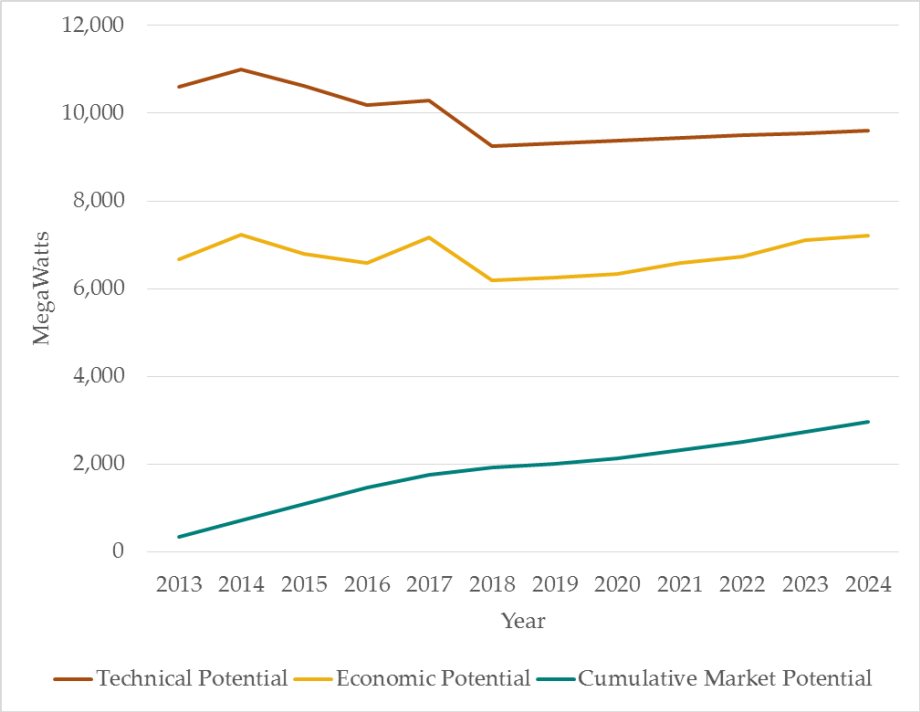
Figure ES-1 and Figure ES-2 illustrate the statewide technical, economic and cumulative market potential for electricity and natural gas respectively. Figure ES-1 shows a technical potential of approximately 38,000 GWh in 2016 and an economic potential of approximately 33,700 GWh. Cumulative market potential grows at a relatively constant rate from 2013 to 2017 when its trajectory slows. This change in trajectory is due to the effects of new lighting C&S that come into effect in 2018 and decrease the IOU claimable savings. Technical and economic potential also decrease in 2018 due to changes in lighting C&S. Figure ES-2 shows a technical potential of approximately 2,000 MMTherms in 2016 and an economic potential of approximately 1,800 MMTherms. Cumulative market potential grows at a relatively constant rate throughout the study period. Section 4.1 of this report contain additional discussion of the technical, economic, and cumulative market potential and also illustrates savings as a percent of energy sales.

Figure ES-1: Statewide Technical, Economic and Cumulative Electric Potential



Source: June 2015 PG Model

Figure ES-2: Statewide Technical, Economic and Cumulative Natural Gas Potential



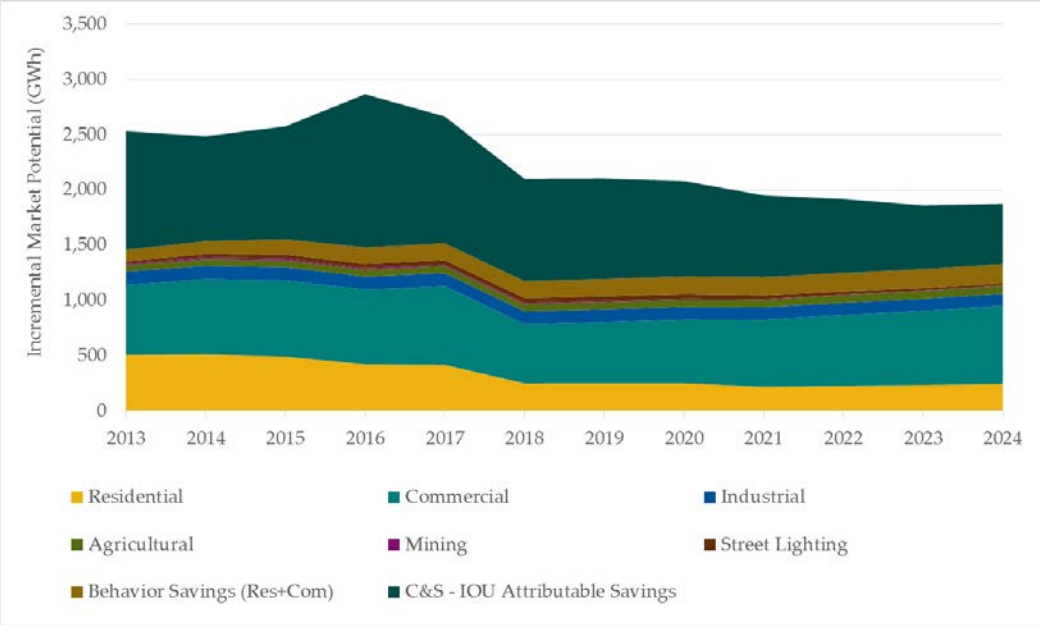
Source: June 2015 PG Model

Figure ES-3 through Figure ES-5 illustrate the statewide incremental market potential from IOU programs for electric (GWh), peak demand (MW) and gas (MMTherms) respectively. These graphs include IOU claimable savings from C&S advocacy programs and behavior programs but they do not include the effects of energy efficiency financing.

Figure ES-3 shows a large portion of IOU potential comes from IOU attributable C&S savings. Residential and Commercial rebated equipment has historically contributed a significant amount of savings to IOU programs and will continue to do so through 2017. In 2018, changes in lighting C&S act to reduce IOU claimable savings. The AIMS sectors remain a small portion of future potential. IOU behavior programs provide more electric savings than the agriculture, mining and streetlighting sectors combined.

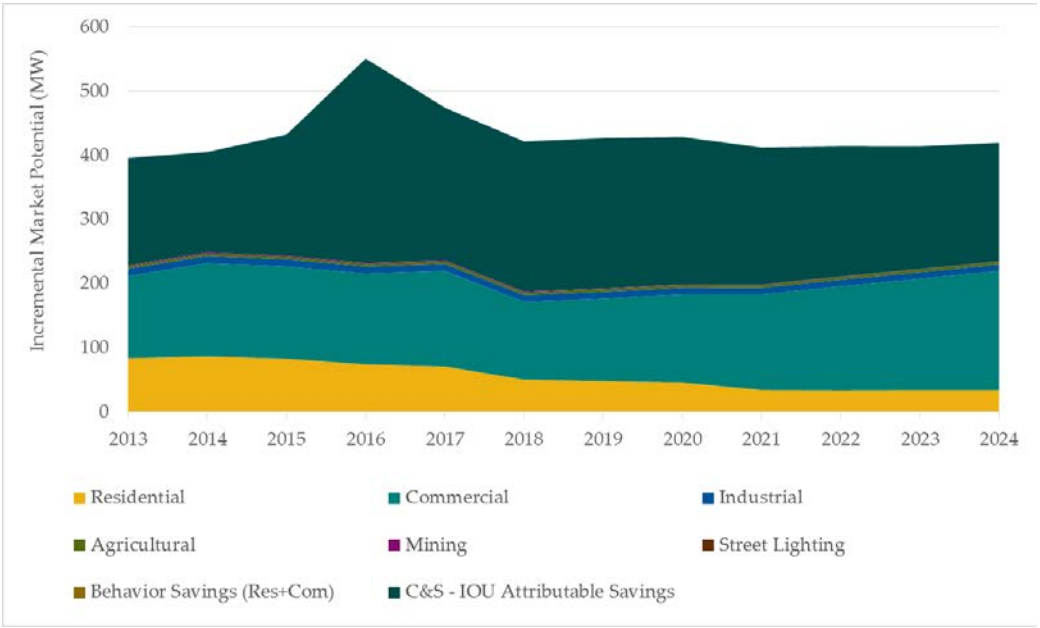
Figure ES-4 shows similar trends for peak demand savings with a few noted differences: behavior programs and street lighting measures do not have any quantified IOU claimable savings potential. Figure ES-4 also shows a spike in expected demand savings in 2016 from C&S. This spike is due to expected 2016 Title 20 HVAC standards regarding air filter labeling.

Figure ES-3: Statewide Incremental Electric Potential



Source: June 2015 PG Model

Figure ES-4: Statewide Incremental Demand Potential

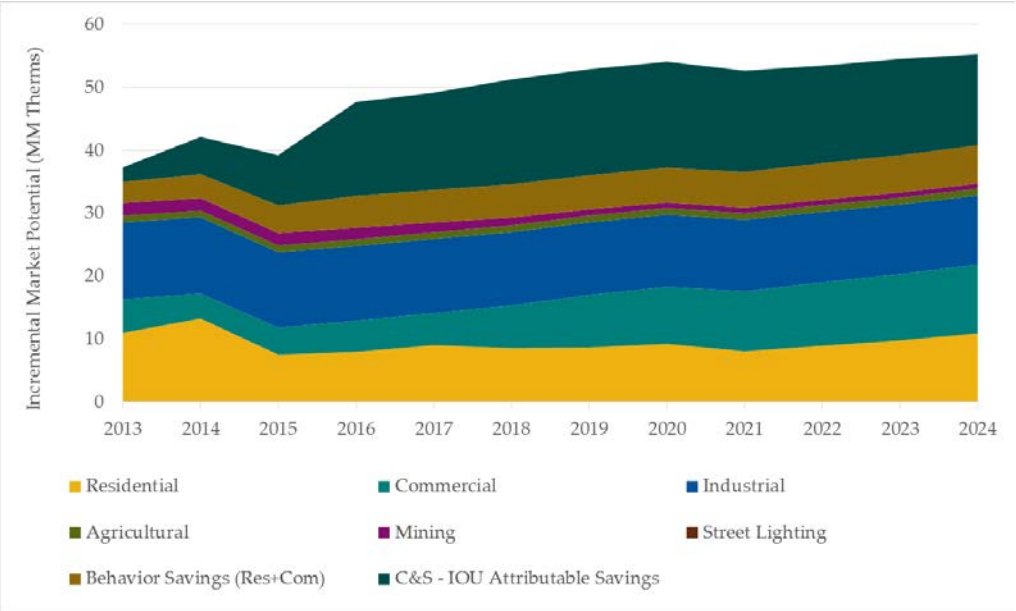


Source: June 2015 PG Model

Figure ES-5 shows larger contributions by the Industrial and Mining sectors towards total gas savings potential. Residential and Commercial savings are expected to grow in 2016 and beyond. C&S savings will continue to play a role in IOU program potential but is not as significant of a contributor when

compared to electric savings. Like electric potential, IOU behavior programs provide more gas savings than the agriculture, mining and streetlighting sectors combined.

Figure ES-5: Statewide Incremental Natural Gas Potential



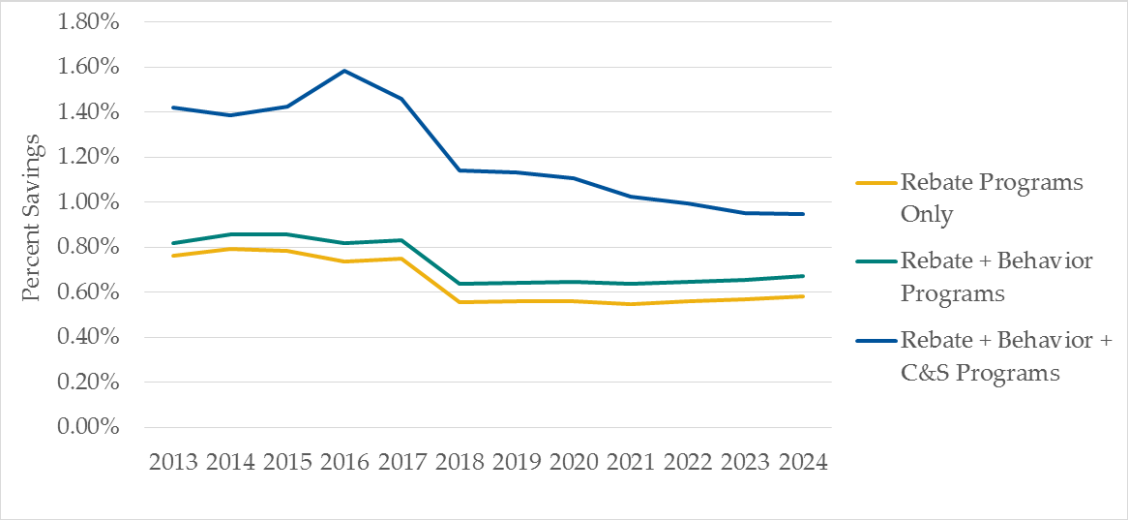
Source: June 2015 PG Model

The proposed Assembly Bill 1330 would create an Energy Efficiency Resource Standard (EERS) in California; a statewide target for electric and natural gas efficiency savings. AB 1330, as currently written, would set the following targets:

- Incremental electric savings achieved of no less than 1.5% in 2020 and 2% in 2025
- Incremental natural gas savings achieved of no less than 0.75% in 2020 and 1% in 2025

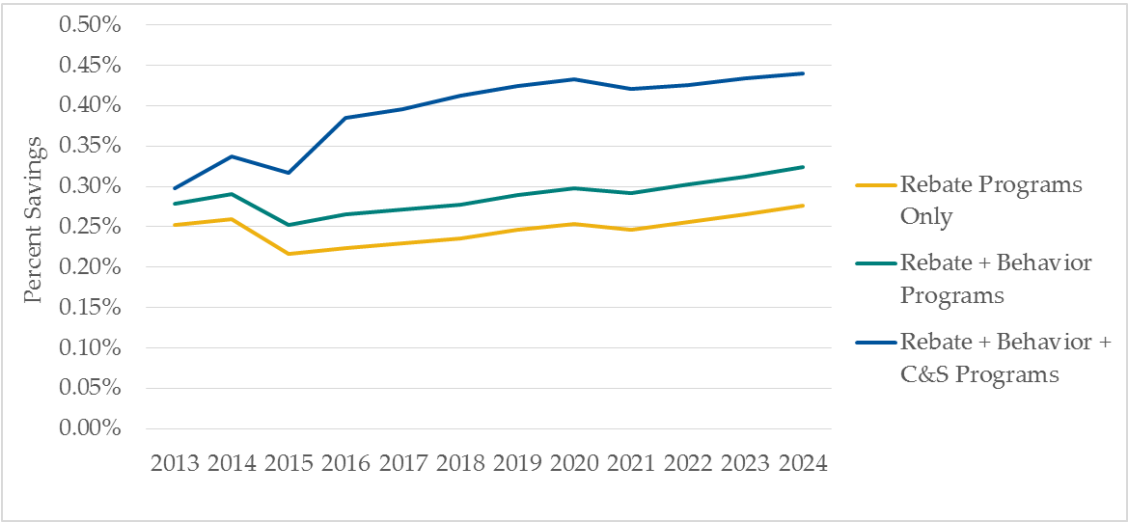
Figure ES-6 illustrates the percent savings in each year considering three sources of savings (rebate programs, behavior programs and IOU C&S programs). It is unclear at this time which sources of savings can and should be counted towards AB 1330 targets. When considering only IOU rebate programs, savings in 2016 amounts to 0.74% of sales. Adding the savings from behavior programs increases the value to 0.82%. The total savings from rebate programs, behavior programs and C&S in 2016 results in 1.58% savings. Savings as a percent of retail sales declines over time. A similar graph for gas savings can be found in Figure ES-7. In all analyzed situations, gas savings is less than 0.5% of CEC forecasted gas sales.

Figure ES-6: Statewide IOU Electric Savings as a Percent of Annual Sales



Source: June 2015 PG Results Viewer

Figure ES-7: Statewide IOU Natural Gas Savings as a Percent of Annual Sales



Source: June 2015 PG Results Viewer

The following tables detail the annual incremental market potential for each IOU from 2016 through 2024. The potential is disaggregated by rebate programs (including behavior programs) as well as net C&S (IOU claimable) savings. Savings values for PG&E and SDG&E include interactive effects (the impact of electric energy efficiency on gas savings) while savings for SCE and SCG exclude these interactive effects. IOU rebate program potential shown in the tables below are gross incremental annual savings while the IOU claimable C&S savings are net IOU attributable annual savings. Savings values for SDG&E further reflect an adjustment to whole building savings to be consistent with CPUC Decision 14-10-046 (further discussion can be found in section 1.4)

Table ES-2: PG&E Market Potential

	GWh			MW			MMTherms		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	624.5	611.3	1,235.9	85.0	140.6	225.6	12.9	5.5	18.4
2017	637.4	506.5	1,143.9	87.4	105.2	192.6	12.9	5.7	18.6
2018	507.4	408.3	915.7	68.9	103.2	172.1	14.8	6.1	20.9
2019	510.9	401.0	911.9	69.6	103.3	173.0	14.9	6.2	21.1
2020	519.1	380.9	900.0	71.4	101.3	172.7	15.5	6.2	21.7
2021	523.9	326.2	850.1	74.4	94.3	168.8	15.9	5.9	21.8
2022	541.2	294.7	835.9	80.3	89.7	170.0	16.7	5.7	22.4
2023	558.2	254.1	812.3	86.3	84.4	170.7	17.5	5.6	23.2
2024	581.3	239.8	821.1	91.7	81.5	173.3	18.6	5.3	23.9

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model

Table ES-3: SCE Market Potential

	GWh			MW			MMTherms		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	673.8	630.5	1,304.4	122.3	145.0	267.3	0.0	0.0	0.0
2017	693.5	522.4	1,215.9	123.0	108.5	231.4	0.0	0.0	0.0
2018	527.7	421.1	948.8	99.4	106.4	205.8	0.0	0.0	0.0
2019	541.8	413.6	955.3	103.1	106.6	209.7	0.0	0.0	0.0
2020	553.0	392.9	945.9	106.9	104.5	211.4	0.0	0.0	0.0
2021	542.4	336.5	878.9	103.3	97.3	200.6	0.0	0.0	0.0
2022	558.8	304.0	862.7	108.6	92.5	201.1	0.0	0.0	0.0
2023	573.2	262.1	835.4	113.2	87.1	200.3	0.0	0.0	0.0
2024	592.8	247.3	840.2	118.8	84.1	202.9	0.0	0.0	0.0

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model

Table ES-4: SCG Market Potential

	GWh			MW			MMTherms		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S**	Total
2016	0.0	0.0	0.0	0.0	0.0	0.0	17.3	11.7	29.1
2017	0.0	0.0	0.0	0.0	0.0	0.0	18.1	12.2	30.3
2018	0.0	0.0	0.0	0.0	0.0	0.0	16.6	12.7	29.4
2019	0.0	0.0	0.0	0.0	0.0	0.0	18.0	12.6	30.6
2020	0.0	0.0	0.0	0.0	0.0	0.0	18.4	12.2	30.6
2021	0.0	0.0	0.0	0.0	0.0	0.0	17.7	10.9	28.6
2022	0.0	0.0	0.0	0.0	0.0	0.0	18.2	10.3	28.5
2023	0.0	0.0	0.0	0.0	0.0	0.0	18.6	9.6	28.2
2024	0.0	0.0	0.0	0.0	0.0	0.0	19.0	9.1	28.1

**Includes behavior programs, excludes effects of financing.*
***Excludes interactive effects*
Source: June 2015 PG Model

Table ES-5: SDG&E Market Potential

	GWh			MW			MMTherms		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	181.0	143.1	324.1	24.5	32.9	57.4	2.6	0.6	3.2
2017	185.0	118.6	303.5	25.7	24.6	50.3	2.7	0.6	3.3
2018	140.8	95.6	236.4	19.6	24.1	43.7	3.2	0.7	3.9
2019	143.7	93.8	237.6	20.1	24.2	44.2	3.2	0.7	3.9
2020	147.3	89.2	236.4	20.9	23.7	44.6	3.3	0.7	4.0
2021	146.6	76.4	223.0	21.1	22.1	43.2	3.0	0.7	3.7
2022	151.3	69.0	220.3	22.5	21.0	43.4	3.1	0.6	3.7
2023	154.4	59.5	213.9	23.4	19.8	43.2	3.2	0.6	3.8
2024	158.1	56.1	214.2	24.5	19.1	43.6	3.2	0.6	3.8

**Includes behavior programs, excludes effects of financing. Includes adjustment for whole building savings to be consistent with CPUC Decision 14-10-046*
Source: June 2015 PG Model

Significant data updates have been made in Stage 1 that cause results to depart from those previously stated in the 2013 Study. A comparison of statewide (all IOUs combined) savings found in Table ES-6 through Table ES-8.

Relative to the 2013 study, overall potential from electric rebate programs decreased slightly between 2016 and 2018 while potential from C&S increased during the same period. Thus total electric potential from 2016 to 2018 increased. Rebate program electric potential after 2018 (after major changes in lighting standards take effect) decrease relative to the 2013 study.

Relative to the 2013 study, overall potential from gas rebate programs decreased on the order of 20% from 2016 through 2024. However, during this same period potential from C&S increased significantly relative to the 2013 study. The net effect of both changes is an overall minimal change to the total potential over the 2016-2024 period though a 9% increase is observed in 2016 and 2017.

The key drivers behind the differences in the results of the two studies are listed below.

- The 2015 study uses more up-to date historic market data for the purposes of model calibration. The 2015 study uses evaluated program results from 2010-12 that was not available in the 2013 study as well as better data about the saturation of equipment from saturation surveys (CLASS and CSS).
- Residential and commercial measures assumptions about unit energy savings were sourced from the DEER2015 Update and 10-12 EM&V studies. Some additional adjustments to CFLs, refrigerator recycling, and commercial lighting were made based on DEER2016 and the Ex Ante Uncertain Measures update.
- The 2015 study used updated measure cost data to characterize residential and commercial measures. The 2013 study in some case relied upon cost data from as early as 2008. HVAC and appliance measures saw the largest changes in cost given this data refresh.
- The CEC proved updated building stock and energy consumption forecasts.
- The updated CPUC evaluation of IOU C&S programs (2010-12 EM&V study) shows more savings than previous evaluation results (2006-08 EM&V study)
- Additional data about IOU behavior programs has generally increased behavior program savings
- Better data on LEDs was obtained. LED assumptions are more conservative in both price and efficacy in the 2015 study relative to the 2013 study. This results in a lower LED potential in the 2015 compared to the 2013 study. In the 2013, much of the increase in potential after 2018 came from LEDs. The post-2018 LED potential is more conservative given data updates.

Table ES-6: 2015 Stage 1 vs. 2013 Study Results: Electric Potential (GWh)

	2013 Study			2015 Stage 1			Difference		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	1,637	937	2,574	1,482	1,385	2,867	-9%	48%	11%
2017	1,600	734	2,334	1,517	1,147	2,665	-5%	56%	14%
2018	1,227	664	1,891	1,177	925	2,102	-4%	39%	11%
2019	1,335	644	1,979	1,196	908	2,105	-10%	41%	6%
2020	1,463	613	2,076	1,219	863	2,082	-17%	41%	0%
2021	1,589	517	2,106	1,213	739	1,952	-24%	43%	-7%
2022	1,720	458	2,178	1,251	668	1,919	-27%	46%	-12%
2023	1,829	366	2,195	1,286	576	1,862	-30%	57%	-15%
2024	1,932	337	2,269	1,332	543	1,875	-31%	61%	-17%

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model, and 2013 Study

Table ES-7: 2015 Stage 1 vs. 2013 Study Results: Demand Potential (MW)

	2013 Study			2015 Stage 1			Difference		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	266	192	458	232	319	551	-13%	66%	20%
2017	268	127	395	236	238	475	-12%	88%	20%
2018	218	123	341	188	234	422	-14%	90%	24%
2019	238	122	360	193	234	427	-19%	92%	19%
2020	262	119	381	199	230	429	-24%	93%	13%
2021	285	109	394	199	214	413	-30%	96%	5%
2022	311	103	414	211	203	415	-32%	97%	0%
2023	335	94	429	223	191	414	-33%	103%	-3%
2024	358	90	448	235	185	420	-34%	105%	-6%

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model, and 2013 Study

Table ES-8: 2015 Stage 1 vs. 2013 Study Results: Natural Gas Potential (MMTherms)

	2013 Study			2015 Stage 1			Difference		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	39.2	7.3	46.5	32.8	17.9	50.6	-16%	145%	9%
2017	39.0	9.1	48.1	33.7	18.5	52.2	-13%	103%	9%
2018	43.5	10.5	54.0	34.6	19.6	54.2	-20%	87%	0%
2019	45.1	11.2	56.3	36.1	19.5	55.6	-20%	74%	-1%
2020	47.1	11.3	58.4	37.3	19.1	56.3	-21%	69%	-4%
2021	48.9	10.2	59.1	36.6	17.5	54.1	-25%	71%	-9%
2022	50.8	10.0	60.8	38.0	16.6	54.6	-25%	66%	-10%
2023	52.4	9.9	62.3	39.3	15.9	55.2	-25%	61%	-11%
2024	54.1	9.7	63.8	40.8	15.0	55.9	-25%	55%	-12%

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model, and 2013 Study

NAVIGANT

1. Introduction

1.1 Context of the Goals and Potential Study

Navigant Consulting, Inc. along with its partners Tierra Resources Consultants LLC, DNV GL, ASWB Engineering, RedHorse Corp, and Opinion Dynamics (collectively known as "the Navigant team") developed this study ("2015 and Beyond Potential and Goals Study") to analyze energy and demand savings potential in the service territories of four of California's investor-owned utilities (IOUs) during the post 2015 energy efficiency (EE) portfolio planning cycle. This report includes results for Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and Southern California Gas (SCG). A key component of the 2015 Potential and Goals Study (2015 Study) is the Potential and Goals Model (PG Model), which provides a single platform in which to conduct robust quantitative scenario analysis that reflects the complex interactions among various inputs and Policy Drivers.

The 2015 Study is the third consecutive potential study conducted by the Navigant team on behalf of the California Public Utilities Commission (CPUC). Navigant conducted the 2011[8] study which informed the 2013-14 IOU program goals and the 2013 Study[9] which was used to inform the 2015 goals for California IOUs. The model developed in the 2013 Study serves as the methodological basis for this study. As such, the 2015 study is considered an "update study" relative to the 2013 Study.

The 2015 Potential and Goals Study supports four related efforts:

1. Inform the CPUC as it proceeds to adopt goals and targets, providing guidance for the next IOU energy efficiency portfolios. The potential model is a framework that facilitates the stakeholder process. The model helps build consensus for goals by soliciting agreement on inputs, methods, and model results.
2. Guide the IOUs in portfolio planning and the state' principal energy agencies in forecasting for procurement, including the planning efforts of the CPUC, California Energy Commission (CEC), and California Independent System Operator (CAISO). Although the model cannot be the sole source of data for IOU program planning activities, it can provide critical guidance for the IOUs as they develop their plans for the 2016 and beyond portfolio planning period. The study is also providing California's principal energy agencies with the tools and resources necessary to develop outputs in a manner that is most appropriate for their planning and procurement needs.
3. Inform strategic contributions to greenhouse gas reduction targets. As the rules and impacts of AB32 are gaining traction, the model must account for (greenhouse gas) GHG savings estimates. This will provide an opportunity to understand how extensively IOU programs and energy

[8] Navigant. *Analysis to Update Energy Efficiency Potential, Goals, and Targets for 2013 and Beyond - Track 1*. May 2012.
[9] Navigant. *2013 California Energy Efficiency Potential and Goals Study*. February 2014. The report is available at http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm.

efficiency can help meet AB32 goals. Navigant will work with the CPUC and stakeholders to develop stretch GHG reduction scenarios.

4. Develop metrics for the CPUC's Energy Efficiency Strategic Plan update.[10] The Plan identifies a number of strategies that move beyond current approaches for energy efficiency resource deployment and lays the groundwork for their implementation. The 2015 Study is expected to inform, as well as be informed by the Plan, by helping to provide metrics, including projections of additional energy savings estimates, for the 2015 Strategic Plan Update Goals. This may include aligning the potential model with strategic plan initiatives, identifying appropriate metrics, characterizing the baseline, developing scenarios, and creating a tracking mechanism.

CPUC policy making informed and directed this study, as outlined in Rulemaking (R.) 09-11-014 and most recently by Decision (D.) 12-05-015, which provided guidance on the 2013-2014 energy efficiency portfolios. D.14-10-046 (Phase I of R.13-11-005) adopted energy efficiency savings goals for 2015 and Phase II of the proceeding will adopt goals for a three year period starting in 2016.[11] The study period spans from 2016-2024 based on the direction provided by CPUC and focuses on current and potential drivers of energy savings in IOU service areas. Analysis of energy efficiency savings in publicly owned utility service territories is not part of the scope of this effort.

The Navigant team and the CPUC have conducted outreach to stakeholders in the development of this model. The comments and questions raised during these meetings have informed the development of the PG Model.

1.2 Scope of this Study

The four primary uses of the 2015 and Beyond Potential Study correspond to the four distinct tasks that will be used throughout the project:

- **Task 1 Potential and Goals Study Update.** This task will inform the CPUC as it proceeds to adopt goals for future IOU energy efficiency portfolios.
- **Task 2: Additional Achievable Energy Efficiency (AAEE) Savings Forecast.** This task will develop savings forecasts for use by CPUC, CEC, and CAISO in long term planning exercises.
- **Task 3: Energy Efficiency Targets for Greenhouse Gas Reductions.** This task will quantify how extensively IOU programs and energy efficiency can help meet AB32 goals.
- **Task 4: Metrics to Support the Strategic Plan Update.** This task will help provide metrics, including projections of additional energy savings estimates, for the 2015 Strategic Plan Update Goals.

The Navigant team is contracted through 2018 to support the development of the PG Model and provide results for each of the four above listed tasks. This report represents the first of multiple updates to the potential study that will occur through 2018. This report focuses on Task 1: Potential and Goals Study Update. Specifically, this report represents the first stage of Task 1 updates (Stage 1). The CPUC and

[10] More information on the Plan can be found at: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/eesp/
[11] Note that the 2016-2018 period is tentative and will ultimately be determined in Phase II of R.13-11-005.

Navigant worked together to determine the appropriate scope of Stage 1 updates given the regulatory timeline for setting 2016 and beyond goals.

1.2.1 Stage 1

Stage 1 of Task 1 is primarily a data update to the PG model to inform 2016 and beyond goals; it is the sole topic of this report. The scope of Stage 1 is to:

- Maintain the 2013 PG Model methodology, infrastructure, architecture, and types of output;
- Correct minor issues where the 2013 PG model methodology is not aligned with current CPUC policy; and
- Rely on new secondary data sources to update the PG model with the latest available information to better inform the 2016 and beyond goal setting process.

The majority of the effort undertaken by the team on Stage 1 was to review and incorporate the latest available data into the study. The CPUC provided the following high level direction to Navigant throughout the data update process:

- Database for Energy Efficient Resources (DEER) data must be incorporated for high impact measures including the DEER2014 Update and DEER2015 Update.[12]
- 2010-12 Evaluation, Measurement, and Verification (EM&V) impact studies should further update DEER data for residential and commercial measures.
- 2010-12 EM&V evaluations should be used to inform updates to Codes and Standards (C&S) analysis, behavior program analysis, and financing analysis.
- The latest California appliance saturation survey studies should be relied upon for key market data.
- In regards to IOU workpapers, the Navigant team should only rely upon those reports that went through a rigorous CPUC review process (however, un-reviewed workpapers could be used to characterize emerging technologies).
- In regards to Industry Standard Practice (ISP) studies, the Navigant team should only rely upon those that are CPUC vetted and approved.

The Navigant team conducted analysis on Stage 1 from November 2014 through June 2015. The majority of the analysis (data collection, model development, and results analysis) was conducted from November 2014 to March 2015. Given the short timeline of Stage 1, the various data update tasks were prioritized by the team along with CPUC input. Table 1-1 lists the Stage 1 key data update activities along with their assigned priority. The priority indicates the relative level of effort allocated to each update activity; high priority items obtained more attention and resources than low priority items. Data collection for high priority updates ended in December 2014 to allow the Navigant team the requisite

[12] The full DEER2016 cannot be incorporated into Stage 1 due to the timeline of the DEER2016 release relative to the timeline of Stage 1. However, the Navigant team did coordinate with the DEER team to best align the study to any new DEER changes and made some high priority adjustments to the potential study in responses based on a draft of DEER2016.

time to review and process the data. Medium and low priority updates continued to receive data through early February at which point data collection activities were stopped in order to deliver draft results on March 17, 2015. Additional, data updates in response to stakeholder comments and CPUC direction were made in early June of 2015, see Section 1.4 for more detail.

Table 1-1: Stage 1 Data Update Priorities

Key Data Update Activity	Stage 1 Priority
Update Residential and Commercial measures with the following data sources: DEER, 10-12 EM&V studies, the Measure Cost Study, and saturation studies	High
Update C&S savings analysis using the 2010-12 impact evaluation study, update methodology to match CPUC policy	High
Update Agricultural, Industrial, Mining, and Street-Lighting to incorporate the latest Industry Standard Practice studies	High
Incorporate the latest non-measure inputs regarding retail rates, building stocks, avoided costs, and utility program costs	High
Update Whole Building Energy Efficiency data using 2010-12 EM&V data, DEER data, CEC building code data, and other available studies	Medium
Update Emerging Technologies data assumptions, specifically review LED assumptions with regards to the California Lighting Quality Standards	Medium
Provide the ability to view measure level results from the model	Medium
Update Behavior and Conservation analysis with latest EM&V and utility data and coordinate with the ongoing CPUC behavior studies	Low
Update Financing analysis with latest EM&V data and coordinate with the ongoing CPUC financing studies	Low

Source: Navigant team discussions with CPUC Staff

1.2.2 Stage 2

Stage 2 will continue to update Task 1 and further refine the data, assumptions, and methodology used to inform the IOU goal setting process. Work on Stage 2 is expected to start in July 2015. The exact scope and timeline for Stage 2 has yet to be determined, the Navigant team is coordinate with the CPUC to better define the scope and schedule. Stakeholders will be invited to participate in the scoping process. The following items are possible updates for Task 1 in Stage 2 (pending further discussions with the CPUC):

- Integrate DEER2016 Update data
- Review Agriculture Industrial, Mining and Street Lighting data to better align with the California market
- Update savings from future codes and standards
- Add new advanced and emerging technologies to the study
- Consider modeling methodology changes as appropriate
- Update whole building initiatives with better cost and market applicability data

1.3 Types of Potential

Consistent with the 2013 Study, the 2015 Study forecasts energy efficiency potential at three levels for rebate programs:

1. **Technical Potential**: Technical potential is defined as the amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve energy efficiency were taken, including retrofit measures, replace-on-burnout measures, and new construction measures. Technical potential represents the immediate replacement of applicable equipment-based technologies regardless of the remaining useful life of the existing measure. Consistent with industry best practices, technical potential does not and is not meant to account for equipment stock turnover. Technical potential represents the potential from individual, equipment based measures. It does not account for behavior programs, IOU claimable savings from codes and standards, or whole building initiatives. In this study, technical potential represents the remaining opportunities for energy efficiency relative to the state of the market as of 2013.
2. **Economic Potential**: Using the results of the technical potential analysis, the economic potential is calculated as the total energy efficiency potential available when limited to only cost effective measures.[13] All components of economic potential are a subset of technical potential. Similar to technical potential, economic potential does not account for equipment stock turnover. The technical and economic potential represent the total energy savings available each year that are above the baseline of the Title 20/24 codes and federal appliance standards.
3. **Market Potential**: The final output of the potential study is a market potential analysis, which calculates the energy efficiency savings that could be expected in response to specific levels of incentives and assumptions about policies, market influences, and barriers. All components of market potential are a subset of economic potential. Some studies also refer to this as "achievable potential." Market potential is used to inform the utilities' energy efficiency goals, as determined by the CPUC.

Market potential can be represented three different ways; each is based on the same data and assumptions though each serve separate needs and provide necessary perspectives.

1. **Incremental savings** represent the annual energy and demand savings achieved by the set of programs and measures in the first year that the measure is implemented. It does not consider the additional savings that the measure will produce over the life of the equipment. A view of incremental savings is necessary in order to understand what additional savings an individual year of energy efficiency programs will produce. This has historically been the basis for IOU program goals.

[13] The default assumption for this study includes all non-emerging technologies with a total resource cost (TRC) test of 0.85 or greater; emerging technologies are included if they meet a TRC of 0.5 in a given year and also achieve the TRC for non-emerging technologies (0.85) within ten years of market introduction. The model includes savings from measure bundles commonly adopted for low income programs; low income programs generally have a TRC less than 0.85 and are not required to be cost effective. These measure bundles are thus included for the purposes of calculating economic potential.

2. **Cumulative savings** represent the total savings from energy efficiency program efforts from measures installed since 2013 including the current program year, and are still active in the current year. It includes the decay of savings as measures reach the end of their useful lives. Cumulative savings also account for the timing effects of codes and standards that become effective after measure installation. This view is necessary for demand forecast, but creates challenges in accounting for IOU program goals.
3. **Life-cycle savings** refer to the expected trajectory of savings from an energy efficiency measure (or portfolio of measures) over the estimated useful life of the measure(s), taking account of any natural decay or persistence in performance over time. Whereas cumulative savings are a backward look at all measures installed in the past that are producing current savings, life-cycle savings accounts for all future savings from measures installed in the current year. Life-cycle savings is used to inform cost-effectiveness evaluations and could be an appropriate basis for IOU program goals.

A large number of variables drive the calculation of market potential. These include assumptions about the manner in which efficient products and services are marketed and delivered, the level of customer awareness of energy efficiency, and customer willingness to install efficient equipment or operate equipment in ways that are more efficient. The Navigant team used the best available current market knowledge and followed these guidelines in developing the recommended market potential:

1. Provide a view of market potential where data sources and calculation methods are transparent and clearly documented.
2. Avoid assumptions and model design decision that would establish goals and targets that are aspirational, but for which the technologies or market mechanisms to attain these goals may not yet be clearly defined.

With these precepts in mind, the Navigant team considers that the market potential presented in this study is a viable basis for energy efficiency forecasting to which load forecasters, system planners, and resource procurement specialists could agree. However, this study may not capture the upper bound on the total amount of energy efficiency that can be achieved. There may be additional energy savings to capture, particularly from systems efficiency and behavior change, which could not be reliably quantified based on past evaluation results available at the time of this study.

1.4 Changes relative to the May 2015 Draft Release

Several data updates have been made to the potential study since the May 2015 release. A draft version of DEER2016 was published for the first time; the release coincided with the potential study's May 2015 release. While the Navigant team was in communication with the DEER team prior to the release, final impacts of key data were unavailable to the Navigant team during the development of MICS. Several updates have been made to the potential study as a result of the DEER team's review of 2010-12 EM&V data and incorporation into DEER2016. Additionally, Navigant reviewed key data sources for the AIMS sectors as well as IOU Low Income Programs. As a result of this data review, the following updates have been made:

- The EUL for all residential CFL measures (basic, specialty, and reflector in indoor and outdoor applications) have been decreased to 3.5 years (previous values ranged from 4.5-11 years depending on the measure). This update was made based on the CPUC's uncertain measure review.[14] This decrease in EUL has two effects: 1) stock turnover of bulbs in the residential sector increases thus slightly increasing the future potential of LEDs, and 2) cumulative savings in the residential sector decreases in future years as CFL savings can only be counted on for 3.5 years.
- Commercial lighting hours of use assumptions have been updated in DEER2016. HOU assumption vary by building type and proportionally impact unit energy savings. In some building types the team observed a 50% decrease in HOUs relative to DEER2015 while other building types remained similar or slightly increased. These changes applied to CFLs, linear fluorescents, and their respective LED equivalents. The net impact of these HOU changes is a decrease in commercial lighting potential. These impacts go into effect starting in 2016 thus calibration is not affected.
- DEER2016 updated the unit energy savings assumptions and net to gross assumptions for residential refrigerator recycling. The unit energy savings decrease on the order of 50% while net to gross increased slightly. The net impact is a significant reduction in savings from residential refrigerator recycling relative to the May 2015 results. These impacts go into effect starting in 2016 thus calibration is not affected.
- Based on verbal and written comments from stakeholders regarding the results from the AIMS sectors, Navigant reviewed key inputs in greater detail. Navigant found a minor update to the AIMS sector was warranted to use the latest available building stock, energy consumption, and building type distribution data available from the CEC. The update lead to a slight decrease in IOU market potential savings.
- Navigant worked with CPUC's low income staff to review and revise the input assumptions regarding low income programs. Savings per participant and estimated number of participants were updated in the model. A key change relative to the May 2015 release is the new assumption that low income programs in their current form will stop operation after 2020, no potential from low income is forecasted in 2021 or beyond. For additional details regarding data updates see Section 3.8.

Navigant made an additional downward adjustment to SDG&E's whole building energy savings at the direction of the CPUC. CPUC Decision 14-10-046 says in regards to whole building savings for SDG&E:

> *"It is going to take some "ramping-up" to achieve such a dramatic increase in savings. Accordingly, we have adjusted SDG&E's 2015 goal to reflect 120% of SDG&E's recent annual savings claims for commercial whole building retrofit programs. This considers (but does not require) a linear, five-year ramp up to the level of savings the draft 2013 Study forecasts for SDG&E."*

The 2015 study shows a decreased savings potential from whole building initiative relative to the 2013 study; however, Navigant made a further adjustment to SDG&E's potential to remain consistent with D.

[14] CPUC. *Ex Ante Update for ESPI Uncertain measures - Compact Fluorescent Lamps 30 Watts and Less.* May 2015.

14-10-046. This adjustment was made based on a 4-year ramp starting in 2016 (similar to the previous 5-year ramp methodology in which 2015 was the first year of the ramp). This ramp assumes 2015 whole building savings for SDG&E are equivalent to the adjusted value found in the SDG&E's 2015 goal and 2019 whole building savings are equal to the 2019 forecast from the PG study. A linear ramp is used between these two years. The result is a small adjustment to SDG&E potential in 2016 through 2018.

1.5 Contents of this Report

This report documents the data relied upon by and the results of the 2015 and Beyond Potential and Goals Study – Stage 1. It does not discuss Task 2, Task 3, or Task 4.

- **Section 2** provides an overview of the study's methodology. Note that the majority of the study's methodology is the same as the 2013 study. Section 2 in many instances refers readers to the 2013 Study for more details on the methodology.
- **Section 3** provides details on the data update process for each key area of the study. Section 3 describes the data sources and process taken to incorporate the data into the PG Model.
- **Section 4** provides the 2015 PG Model results.
  - Section 4.1 discusses the statewide (all IOUs combined) technical, economic and market potential in California.
  - Section 4.2 contains the incremental market potential for each IOU, these are the basis for the IOU goal setting process.
  - Section 4.3 documents the effects of energy efficiency financing on the market potential.
  - Section 4.4 describes how readers can access detailed results from the PG study include end use and sector specific results for each IOU.
  - Section 4.5 compares the results of this study to the results of the 2013 Study.
- **Appendices** provide additional details for key topic areas.

Aside from this report, the following are available to the public:

- **2015 PG Model File** – an Analytica based file that contains the PG model used to create the results of this study;
- **2015 PG Results Viewer** – a spreadsheet viewer that contains detailed results at the measure level for the mid-case scenario (the basis of the results of this study); and
- **2015 PG MICS** – a spreadsheet version of the Measure Input Characterization System documenting all final values for all measures used in the model.

These additional documents and files can be found on the CPUC's website.[15]

[15] http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

2. Study Methodology

2.1 Modeling

The primary purpose of the 2015 Study is to provide the CPUC with information and analytical tools to engage in goal setting for the next IOU energy efficiency portfolio. In addition, this study informs forecasts used for procurement planning. The model itself does not establish any regulatory requirements. This section provides a brief overview of the modeling methodology used for the 2015 Potential and Goals Study. The modeling methodology remains the same as that used in the 2013 Study. For more information on the specific methodology for different parts of the model, please reference the 2013 Study report.

The 2015 model forecasts potential energy savings from a variety of sources within six distinct sectors: Residential, Commercial, Agricultural, Industrial, Mining, and Street Lighting. Within some or all of the sectors, sources of savings include:

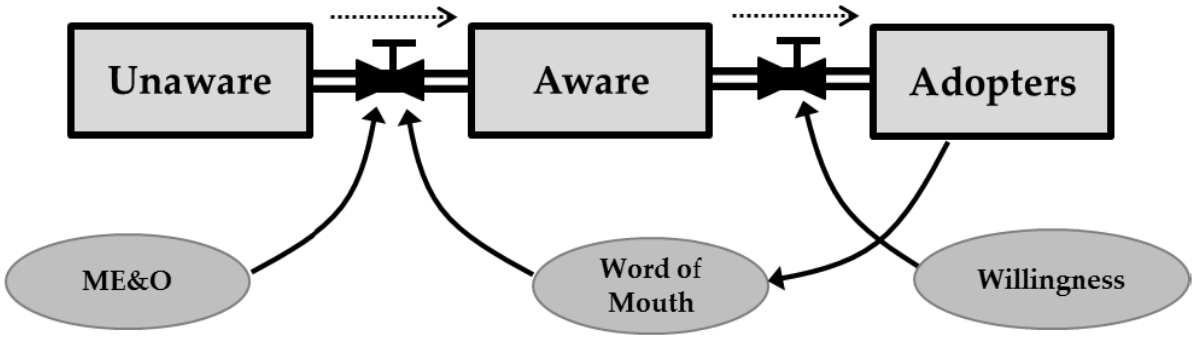
- Emerging Technology – Emerging technologies were examined for the Residential, Commercial, and Street-lighting sectors. These sectors are modeled using individual measures for specific applications.
- Behavior - For the purposes of this study, the Navigant team defines behavior-based initiatives as those providing information about energy use and conservation actions, rather than financial incentives, equipment, or services.
- Financing - Financing has the potential to break through a number of market barriers that have limited the widespread market adoption of cost-effective energy efficiency measures. The PG Model estimates the incremental effects of introducing energy efficiency financing on energy efficiency market potential and how shifting assumptions about financing affect the potential energy savings.
- Whole Building - In the case of whole-building initiatives, the "measure" is characterized for the building retrofit or house retrofit rather than for specific technology or end uses. Whole building initiatives are modeled for the Residential and Commercial sectors.
- Low Income – The methodology for the low-income sector remains unchanged from the 2013 Study. Data was updated to reflect the most recent information available from the CPUC regarding savings per participant and forecasted participants.
- Codes and Standards - Codes and standards are implemented and enforced either by federal or state governmental agencies. Codes regulate building design, requiring builders to incorporate high-efficiency measures. Standards set minimum efficiency levels for newly manufactured appliances. The Navigant team assessed energy savings potentials for three types of C&S:
    - Federal appliance standards
    - Title 20 appliance standards
    - Title 24 building energy efficiency codes

Consistent with the 2013 Study, the 2015 PG Model forecasts three levels of energy efficiency potential (technical, economic, and market) as described earlier in section 1.3 To estimate the market potential for the Residential, Commercial, Mining, and Street Lighting sectors, the model employs a bottom-up

dynamic Bass Diffusion approach to simulate market adoption of efficient measures. The bass diffusion model is illustrated in Figure 2-1 and contains three parameters:

- ***Marketing, education, and outreach*** (ME&O) moves customers from the *unaware* group to the *aware* group at a consistent rate annually. Unaware customers, as the name implies, have no knowledge of the energy efficient technology option. Aware customers are those that have knowledge of the product and understand its attributes. ME&O is often referred to as the "Advertising Effect" in Bass Diffusion modeling.
- ***Word of mouth*** represents the influence of adopters (or other aware consumers) on the unaware population by informing them of efficient technologies and their attributes. This influence increases the rate at which customers move from the unaware to the aware group; the word-of-mouth influence occurs in addition to the ongoing ME&O. When a product is new to the market with few installations, often ME&O is the main source driving unaware customers to the aware group. As more customers become aware and adopt, however, word of mouth can have a greater influence on awareness than ME&O, and leads to exponential growth. The exponential growth is ultimately damped by the saturation of the market, leading to an S-shaped adoption curve, which has frequently been observed for efficient technologies.
- ***Willingness*** is the key factor affecting the move from an aware customer to an adopter. Once customers are aware of the measure, they consider adopting the technology based on the financial attractiveness of the measure. The PG Model applies a levelized measure cost to assess willingness; the levelized measure cost considers upfront cash outflows as well as cash outflows

Figure 2-1: The Bass Diffusion Framework is a Dynamic Approach to Calculating Measure Adoption



Source: Adapted from Sterman, 2000.

The Navigant team calculated energy efficiency potential in the industrial and agricultural sectors using a top-down supply curve approach as detailed in the 2013 Study report.

Like the 2013 PG model, the 2015 model was developed in the Analytica software platform. The inputs and user interface are designed for customizability and ease of use. Figure 2-2 depicts a screenshot of the model user interface.

Figure 2-2: The 2015 Potential Goals Model User Interface

2.2 *Methodology Changes Relative to 2013 Study*

As previously mentioned, the modeling methodology remains largely the same as the 2013 study. Table 2-1 lists the key modeling methodology topics, along with the relevant methodology sections from the 2013 study. Readers should reference the 2013 study for additional modeling methodology details. The only noted methodology change from the 2013 study is the treatment of codes and standards; this difference is further explained following the table.

Table 2-1: Comparing 2015 and Beyond Methodology to 2013 Study

Methodology Topic	Modeling Methodology used in this Study	2013 Study Relevant Methodology Sections
Forecasting Adoption of Rebated Measures	Same as 2013 Study	3.3.1 3.3.2.1
Agriculture, Industrial, Mining and Street Lighting Special Considerations	Same as 2013 Study	Section 4 Appendix G – J Appendix T
Emerging Technologies Special Considerations	Same as 2013 Study	3.1.1.1
Whole Building Initiatives Special Considerations	Same as 2013 Study	3.3.2.3 Appendix E
Modeling Behavior Energy Efficiency Initiatives	Same as 2013 Study	3.3.2.5
Modeling Energy Efficiency Financing	Same as 2013 Study	3.3.2.4 Appendix F
Modeling Codes and Standards (Impact on IOU Rebate Programs)	Same as 2013 Study	3.3.2.2 Appendix D.1 Appendix D.2
Modeling Codes and Standards (IOU Attributable Savings)	Modified relative to 2013 Study	3.3.2.2 Appendix D.3

Source: Navigant team analysis (2015)

The 2015 PG Model's analysis of IOU attribute Codes and Standards (C&S) savings follows the same methodology as that used in the 2013 study with one update. Some new California standards supersede efficiency levels set by earlier standards. Two options are available to model the IOU attributable savings these types of standards:

- **Layering:** The first standard produces the first "layer" of savings and each later standard adds another layer of savings.
- **No Layering:** Savings from earlier superseded standards end when a new, more stringent standard takes effect. Only incremental savings from the most recent standard are included.

The CPUC 's Evaluation Study[16] used the Integrated Standards Savings Model[17] developed by CADMUS and DNV GL. Commission staff and evaluators reviewed all of the codes and standards being evaluated in the ISSM model. To qualify as an instance of layering, standards must be adopted separately (not at the same time, as happens when one standard includes two tiers that take effect at different times).

[16] Cadmus, Energy Services Division and DNV GL. *Statewide Codes and Standards Program Impact Evaluation Report For Program Years 2010-2012.* August 2014.
[17] Cadmus, Energy Services Division and DNV GL. *Integrated Standards Savings Model (ISSM).* Last accessed: January 2015.

Additionally, the superseding code or standard must regulate the same feature(s) of a product.[18] See section 2.2.2 of the Evaluation Study for further details.

Stage 1 uses no layering when calculating results. This is a methodology change relative to the 2013 study which did include layering in accounting for IOU attributable savings. This change is made to the methodology to better align with CPUC policy regarding savings accounting for C&S. The measures that were superseded by later standards and thus are affected by this methodology change were General Service Incandescent Lamps, Tier 2 and Consumer Electronics – TVs.

2.3 Model Calibration

Like any model that forecasts the future, the PG model faces challenges with validating results, as there is no future basis against which one can compare simulated versus actual results. Calibration, however, provides both the developer and recipient of model results with a level of comfort that simulated results are reasonable. Calibration is intended to achieve three main purposes:

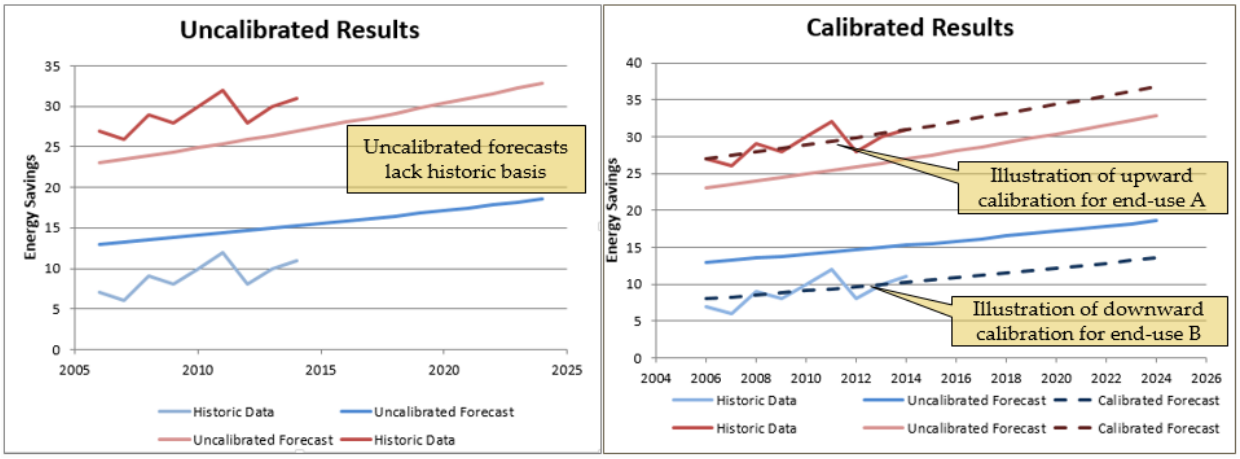
- Anchors the model in actual market conditions and ensures that the bottom-up approach to calculating potential can replicate previous market conditions;
- Ensures a realistic starting point from which future projections are made; and
- Accounts for varying levels of market barriers across different types of technologies. The model applies general market and consumer parameters to forecast technology adoption. There are often reasons that markets for certain end uses or technologies behave differently than the norm- both higher and lower. Calibration offers a mechanism for using historic observations to account for these differences.

The PG model is calibrated by reviewing portfolio data from 2006 up through 2012 to assess how the market has reacted to program offerings in the past. The Navigant team used ex-post EM&V data from 2006-2012 as the calibration data and also compared results to the 2013-2014 compliance filing data. The 2013-2014 data was not incorporated into the model calibration because the evaluated data set is not yet available. The Navigant team used the calibration data to adjust willingness and awareness parameters that drive measure adoption over the modeling period. This calibration method (a) tracks what measures have been installed or planned for installation over an historic eight-year period and (b) forecasts how remaining stocks of equipment will be upgraded, including the influence of various factors such as new codes and standards, emerging technologies, or new delivery mechanisms (e.g., financing or whole-building initiatives). This calibration approach is not applied to emerging technologies, as there is no historical basis to adjust future adoption for these technologies.

Figure 2-3 provides a conceptual illustration of how the calibration process affects market potential.

[18] Cadmus, Energy Services Division and DNV GL. *Statewide Codes and Standards Program Impact Evaluation Report For Program Years 2010-2012.* August 2014.

Figure 2-3: Conceptual Illustration of Calibration Effects on Market Potential



Source: Navigant team analysis 2015.

Calibration provides a more accurate estimate of the current state of customer willingness, market barriers, program characteristics and remaining adoption potential. Although calibration provides a reasonable historic basis for estimating future market potential, past program achievements may not perfectly indicate the full potential of future programs. Calibration can be viewed as holding constant certain factors that might otherwise change future program potential, such as:

- Consumer values and attitudes toward energy efficient measures;
- Market barriers associated with different end uses;
- Program efficacy in delivering measures; and
- Program spending constraints and priorities.

Changing values and shifting program characteristics would likely cause deviations from market potential estimates that are calibrated to past program achievements. For more details on the necessity of calibration, the data basis of calibration, effects of calibration, and interpreting calibration please see Appendix A. The appendix also addresses the irrelevance of an "uncalibrated" forecast while offering a supporting discussion about scenario analyses not directly related to the process of calibration but relevant to stakeholder concerns about the interpretation of calibrated results.

2.4 Scenarios

The PG model can run numerous scenarios based on changes to key variables. The 2015 PG Model maintains the same scenario variable options as the 2013 PG model (additional information is available in section 3.3.4 of the 2013 Study). This report presents the results for the mid-case scenario.

- The mid-case scenario has historically been used to inform the IOU goal setting process.
- The mid case scenario is the default setting that the PG model uses to produce results.
- The mid-case scenario in this report retains the same assumptions used in the mid-case scenario in the 2013 study.

» The mid-case scenario is based on population, consumption, and economic inputs defined in the mid-case of the California Energy Commission's 2014 Integrated Energy Policy Report (IEPR).

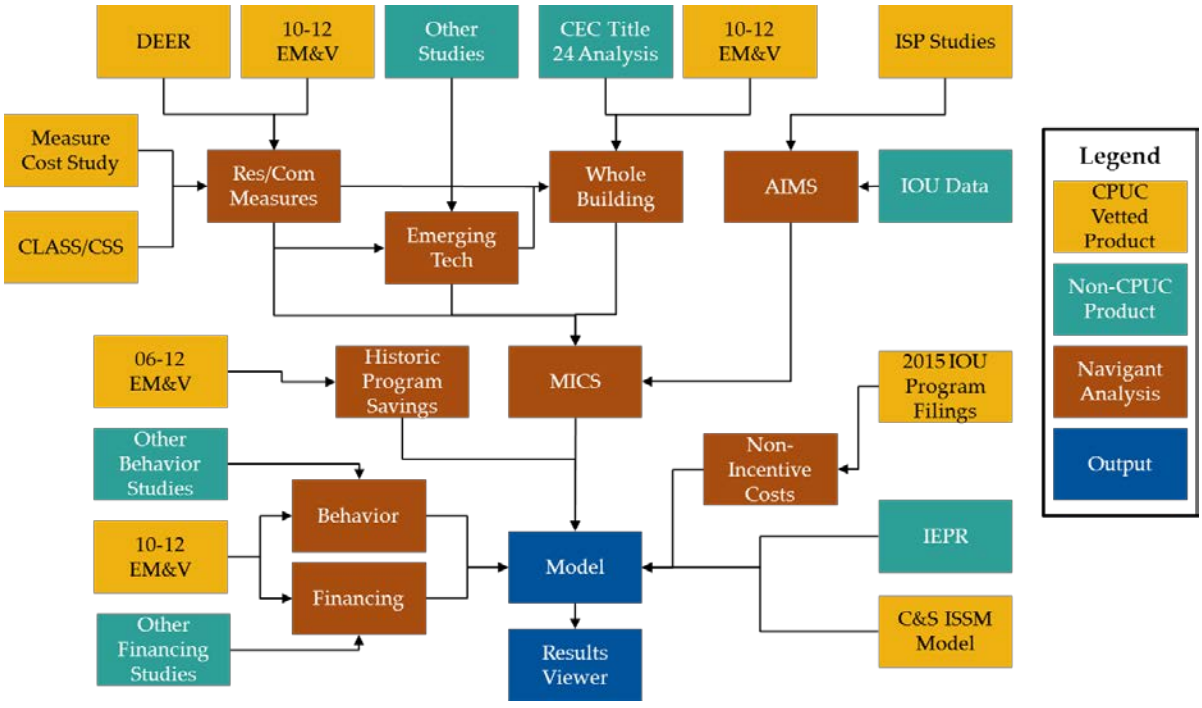
The Navigant team is in the process of developing alternate scenarios. The 2013 study produced additional scenarios (referred to as Additional Achievable Energy Efficiency [AAEE]) to support the 2013 IEPR update process. The CPUC, CEC, and CAISO collaborated to develop an estimate of the energy efficiency savings forecast that could be realized through utility programs that are incremental to the savings already incorporated in the IEPR baseline forecast. The Navigant team will continue to work with the CEC to define the appropriate low and high scenarios to use.

3. Data Sources

As mentioned previously, Stage 1 of Task 1 (Potential and Goals Study Update) is primarily a data update to the PG model to inform 2016 and beyond goals. The majority of the effort undertaken by the team on Stage 1 was to review and incorporate the latest available data into the study.

The data sources relied upon in Stage 1 are vast and varied. Figure 3-1 below illustrates the various produces relied upon for data that feed Navigant analysis that ultimately informs the output of this study. Throughout the data update process, the Navigant team sought to rely upon CPUC vetted products as much as possible. However, in several cases, the team needed to seek alternate data sources where CPUC products did not provide the necessary information. This chapter describes the data update process and sources for key topic areas. The discussion only focus on new data used to inform the Stage 1 of the 2015 Study. In some cases data was not updated and data from the 2013 study was "passed through" to Stage 1; each of the following sections describes what data was "passed through" from the 2013 study.

Figure 3-1: Stage 1 Data Map



3.1 Global Inputs

Global inputs are macro-level model inputs that are not specific to any measure, but rather apply to market segments or sectors. Navigant reviewed the data source for each of these inputs to ensure that the most recent data is utilized for 2015 PG Model update. Table 3-1 provides an overview of all the

global inputs within the 2015 model, whether or not the input was updated, and the data source for that update. Each item in Table 3-1 is discussed in further detail in the subsections that follow the table.

No updates were made to the avoided costs, which come from each IOU's Avoided Cost model. Navigant will review these Avoided Cost models again Stage 2 to check for updates.

Table 3-1: Overview of Global Inputs Updates and Sources

Global Input *(description)*	Updated in Stage 1?	Data Source for Update
Building Stocks *(households, floor space, consumption)*	Yes	CEC - *2014 Integrated Energy Policy Report (IEPR) Update and Demand Forecast Forms.* Adopted Feb. 2015. Excel Demand Forecast Forms available at: *http://www.energy.ca.gov/2014_energypolicy/documents/index.html#adoptedforecast*
Retail Rates *($/kWh, $/therm)*	Yes	
Sales Forecasts *(GWh, MW, and MM Therms)*	Yes	
Avoided Costs *(Avoided energy and capacity costs)*	No	No Update in Stage 1, "passed through" from 2013 Study
Historic Program Accomplishments *(Used for calibration)*	Yes	CPUC - *EE Program Tracking Database* Accessed: November 2014
Non-Incentive Program Costs *(formerly Admin. Costs)*	Yes	CPUC - 2015 IOU Planning Submissions - *IOU-2015-Filing-Review-4-17-204.xlsm* Accessed: March 2015

3.1.1 Building Stocks

Building stocks are the total "population" metrics of a given sector, though represented by different metrics for most sectors. Residential building stocks are based on number of households in an IOU's service territory. Commercial building stocks are represented by total floor space for each commercial building type. Industrial and agricultural building stocks are represented by energy consumption. Mining and Street lighting stocks are the number of pumps and streetlights respectively. The residential, commercial, industrial and agriculture building stock metrics are derived from the CEC's IEPR, which is updated yearly by the CEC. Navigant updated the building stocks to reflect the recently released IEPR 2014, adopted by the CEC in February 2015. Sources for mining and street lighting building stocks are discussed further in section 3.4.

Navigant recognizes that within the CEC's IEPR forecast, PG&E and SCE baseline demand forecasts include consumption from Publicly Owned Utilities (POUs) in addition to IOU consumption. The CEC provided Navigant with ratios to adjust the planning area consumption (found within IEPR) down to each IOU's actual service territory consumption for both PG&E and SCE. These ratios, based on 2014 IEPR, are referred to as Service Territory to Planning Area adjustment ratios and are detailed in Table 3-2.

Table 3-2: IEPR Electric Service Territory to Planning Area Adjustment Ratios

	Residential	Commercial	Industrial	Mining	Agriculture	Streetlights
PG&E	90.1%	83.0%	76.6%	86.2%	86.1%	92.0%
SCE	94.0%	91.8%	87.9%	95.7%	62.4%	99.7%

Source: California Energy Commission, 2015

Most POUs in CA do not offer any gas service (currently only the City of Palo Alto and Island Energy offer natural gas service). Due to this, these Service Territory to Planning Area ratios only apply to the electric forecasts of PG&E and SCE. Additionally, PG&E's Gas service territory is larger than its electric service territory to include the SMUD Planning Area, which is reflected within both the 2013 and 2015 PG Models.

3.1.2 Retail Rates and Sales Forecasts

The CEC's IEPR is also the source for retail rates and sales forecasts within the 2015 Study, utilizing 2014 IEPR for the electric rates and sales forecasts and 2013 IEPR for the gas rates and sales forecasts. This was because only electric rates and forecasts were updated in the recently released 2014 IEPR. Updates to the natural gas rates and forecasts are expected this later in 2015 and will be utilized in Stage 2 if they are available. As comparison, the 2013 Study utilized the 2013 IEPR for its sales forecasts and retails rates for both electricity and natural gas. The aforementioned Service Territory to Planning Area ratios were applied to the PG&E and SCE sales forecasts as well.

3.1.3 Historic Rebate Program Achievements

One of the Residential and Commercial sector inputs important for calibration purposes is the historic rebate program achievements for each of the IOUs. These include the ex-post gross program achievements from both the 2006-2009 and 2010-2012 (06-09 and 10-12 hereinafter) program cycles as reported and evaluated by the CPUC. For both the 2013 and 2015 Studies, Navigant obtained these achievements from the CPUC's Standard Program Tracking Database (SPTdb). These achievements are used to inform the historic modeling period and used to calibrate future model projections to account for past program activities. Additional discussion of the calibration process can be found in Appendix A.

The CPUC requires that ex-post gross achievements be utilized whenever possible. In the 2013 Study, the evaluation of the 06-09 program cycle had already been complete and the gross ex-post achievements were utilized in the 2013 Study. These 06-09 achievements were unchanged in Stage 1.

For Stage 1, the historical program achievements for the 10-12 program cycle were updated. The 10-12 program cycle had not been fully reported or evaluated when calibration data was collected for the 2013 PG Study. These evaluations have since completed and the data was obtained in November 2014 for use in Stage 1. The 2013-14 evaluated program achievements are not yet available. Table 3-3 provides the updated 2010-2012 gross ex-post savings utilized in Stage 1.

Table 3-3: 2010-2012 IOU Portfolio Gross Ex-Post Program Savings

	Energy Savings (GWh)		Gas Savings (MM Therms)	
	RES	COM	RES	COM
PG&E	1,743.7	1,249.7	-19.3	23.1
SCE	2,312.4	1,235.1	NA	NA
SCG	NA	NA	24.4	30.1
SDG&E	308.3	300.6	-0.6	7.0

Source: Navigant analysis of Standard Program Tracking Database. 2014 (includes HVAC Interactive Effects)

Appendix A contain tables detailing residential and commercial end use level historic achievements for all years from 2006-2012. Navigant mapped its modeling end-uses to those found within SPTdb, therefore end-use level data may not match exactly. Some program savings were not modeled (such as 'C&S', 'other' or 'unknown' programs) and those savings are included as 'NA' in these tables. Additionally, CFL upstream lighting savings were split between the Residential and Commercial sectors only (52% and 48% respectively) based on the KEMA's Final Evaluation Report: Upstream Lighting Program prepared for the CPUC.[19]

3.1.4 Non-Incentive Program Costs

Non-incentive program costs underwent a thorough review and update based on the 2015 IOU Compliance Filings submitted to the CPUC and found on the DEER website.[20] The 2015 Compliance Filings were utilized since these are most indicative of future non-incentive program costs. These costs were referred to as simply "Administrative Costs" in the 2011 and 2013 Studies, however, this instilled confusion because these include more than simply utility administrative costs. The title was therefore changed to non-incentive program costs, and includes administrative, market/outreach, and implementation (customer service) costs, taken from the 'Program Summary' tab of each IOU's 2015 compliance filings. State and local government partnerships are excluded because they are target exempt programs. Due to high variation in of costs in the agricultural and industrial sectors, a weighted average of Non-Incentive Program Costs for these sectors was applied to the all of AIMS. Table 3-4 provides an overview of the Non-Incentive Program Costs utilized in Stage 1.

[19] CPUC. *Final Evaluation Report: Upstream Lighting Program Volume I.* Prepared by KEMA, Inc., Feb. 2010

[20] Available at ftp://ftp.deeresources.com/E3CostEffectivenessCalculators/2015IOUsubmissions/ Last Accessed: March 2015

Table 3-4: Non-Incentive Program Costs Summary – 2015 Compliance Filings

	Energy - $/kWh Saved			Gas - $/Therm Saved		
	RES	COM	AIMS	RES	COM	AIMS
PG&E	$0.164	$0.147	$0.095	$3.879	$3.393	$1.637
SCE	$0.141	$0.166	$0.216	NA	NA	NA
SCG	NA	NA	NA	$6.580	$9.536	$13.063
SDG&E	$0.201	$0.095	$0.234	$5.627	$2.262	$7.710

Source: Navigant analysis of 2015 IOU Compliance Filings

3.2 Residential and Commercial Measure Characterization

This section provides an overview of the Navigant team's approach to updating the Residential and Commercial Measure Characterization used in Stage 1. The approach used for the 2013 Study is carried over for the 2015 Study. For the 2013 Study, the Navigant team compiled an extensive set of measure-level data for the two sectors into an online database. To develop the 2013 study measure-level data, the Navigant team combined information from multiple versions of the Database for Energy Efficient Resources (DEER),[21] the Frozen Ex Ante (FEA) database,[22] various IOU workpapers, and saturation studies. Navigant's Measure Input Characterization System (MICS) Online provided a platform for stakeholders to access, review, and provide feedback on measure characterization data. For additional detail regarding the key input variables and initial data sources in the MICS, please refer to the 2013 Study.

For Stage 1 of the 2015 Study, Navigant developed a methodology to refresh the existing MICS with data published after the 2013 Study was completed. The overall architecture of the MICS remained largely the same from 2013 to 2015. This section provides additional detail on the types of measure-level data updates and the sources of each type of input.

The MICS database houses approximately 65,000 unique rows of Residential and Commercial measure characteristics that allow the calculation of technical, economic, and market potential for each measure by climate zone, building type, and service territory. Each of the 65,000 rows of data consists of 87 data parameters that define the measure.

[21] The Database for Energy Efficient Resources (DEER) contains information on energy efficient technologies and measures. This information includes energy consumption and savings, costs, and other supporting data required to calculate cost-effectiveness and willingness. DEER has been developed for the CPUC through funding from California ratepayers. Interested parties can access DEER at www.deeresources.org.

[22] The FEA (Frozen Ex Ante) is a database developed for the CPUC to house all approved measure-level ex ante data. This includes data on DEER and non-DEER measures. The FEA is housed by the CPUC's Energy Division (ED) on an internal server; access to the FEA data can be requested from ED.

3.2.1 DEER Data

Many of the measures in the MICS developed in the 2013 Study relied on DEER data. Since the 2013 Study was completed, DEER was updated and approved by the CPUC twice due to changes in applicable codes and standards and other minor requests.[23] As such, Navigant updated affected MICS measures with the most recent DEER data. The following DEER updates were included in Stage 1:

- DEER2014 Update: This update was the result codes and standards changes, particularly the California Title 20 Appliance Efficiency Regulations and the California Title 24 Building Energy Efficiency Standards. DEER2014 impacted ex ante unit energy savings for HVAC measures, lighting measures, water heating measures, and other weather-sensitive measures.
- DEER2015 Update: An incremental update to DEER2014 based on United States Code of Federal Regulations, this update affected specific technology groups included in the MICS. The technology groups included split and package air conditioning equipment, water heaters, and gas furnaces.

Navigant collaborated with the Ex Ante Team to fully understand the updates and coordinate the incorporation of the DEER2014 Update and DEER2015 Update data. This collaboration ensured Navigant had the most up-to-date DEER data available for the affected measures and could direct any necessary changes to fundamental structure of those measures. For each affected measure, Navigant extracted data from the DEER database and reconstructed the MICS measure workbooks with the new data. Where necessary, Navigant modified the code and efficient equipment specifications in the measure definitions to match those of the updated unit energy savings data. For more information regarding the integration of DEER data into the MICS, please refer to the 2013 Study.

More recently a draft version of DEER2016 has been released. The CPUC requested Navigant make several critical updates to MICS in response to DEER2016. These updates affected commercial lighting and refrigerator recycling measures (previously discussed in Section 1.4). The team was unable to incorporate the full DEER2016 into Stage 1 due to the timeline of the DEER2016 release relative to the timeline of Stage 1.

3.2.2 2010-12 EM&V Data

Because of the high volume of data in the MICS, Navigant developed a method to prioritize the measure updates based on EM&V data for Stage 1. In general, Navigant selected measures that contributed the greatest to the potential impact in the 2013 Study. Defined as High Impact Measures (HIMs), these measures represented 90% of the potential impact within each sector (Residential and Commercial) and fuel type category (electric and gas).

Table 3-5 presents a count of the measures by Sector, Fuel Type, and End-Use Category included in the EM&V update priority list. Although the list contains most of the updated measures, measures with lower potential impact were also included if they were analogous or related to HIMs. For example, if the baseline unit energy consumption for an HIM changed, the baseline unit energy consumption for all

[23] Updates to DEER outside of the DEER Update process can be found on the change log at http://deeresources.com/files/deerchangelog/deerchangelog.html.

related measures was changed regardless of the potential impact. These corollary updates help to maintain consistency throughout the MICS measures.

Table 3-5: Residential and Commercial Measures Included in the Stage 1 EM&V Data Update

Sector	Fuel Type	Use Category Definition	Use Category Examples	Measure Count
Com	Electric	Lighting	Linear Fluorescents, CFLs, Occupancy Sensors, High-Bay T5s, HIDs	13
Com	Electric	HVAC	A/C and Heating Units, Chillers	7
Com	Electric	Plug-in Appliances/Electronics	Vending Machine Controls, Desktop Computer Power Management	2
Com	Electric	Service/Non-Equipment	HVAC Fault Detection and Diagnostics	1
Com	Electric	Whole-building	HVAC Energy Management Systems	1
Com	Gas	HVAC	Boilers, Thermostats, Furnaces	6
Com	Gas	Service Hot Water	Pipe and Tank Insulation	2
Com	Gas	Whole-building	HVAC Energy Management Systems	1
Com	Gas	Food Service	Fryers	1
Res	Electric	Lighting	CFLs, Plug-In Fixtures, Seasonal Lighting	11
Res	Electric	Plug-in Appliances/Electronics	Refrigerator Recycling, Computer Monitors, Variable Speed Pool Pumps	4
Res	Gas	Service Hot Water	Storage Water Heaters, Instantaneous Water Heaters	2
Res	Gas	HVAC	Furnaces, Duct System Repair	2
Res	Gas	Plug-in Appliances/Electronics	Clothes Washers	1

Source: Navigant team analysis (2015)

Table 3-6 presents the EM&V studies Navigant reviewed and sourced for relevant data updates in Stage 1. Navigant focused the updates on the following key measure parameters:

- Unit energy savings (or factors that contribute to unit energy savings, such as hours of use)
- Equipment specification distributions (e.g., CFL wattages to calculate a weighted average lamp wattage)
- Measure costs
- Measure densities

Navigant engaged the primary authors of the studies during the process to facilitate data transfer and understanding of the available data. The coordination resulted in Navigant's retrieval of data from the full impact evaluation and study databases beyond the data available from within the written report.

Notably, the available studies did not have data applicable to all HIMs, thus some HIMs remained unchanged from the 2013 Study. Similarly, the MICS measures are built from many parameters, and not all parameters are within the scope of or were updated during the EM&V studies. Thus, some parameters of MICS measures remained unchanged from the 2013 Study. Given the timeline of Stage 1, Navigant updated measures based on the EM&V results conservatively, updating measure parameters for which there was a high degree of certainty that the new data were consistent with and an exact matches to the existing parameters.

Table 3-6: EM&V Studies Used for Stage 1 Measure Updates

Author	Study Title	Publication Date	Relevant Data
DNV GL	*Appliance Recycling Program Impact Evaluation*	October 2014	Unit energy savings and net to gross for refrigerator recycling measure
DNV GL	*California Upstream and Residential Lighting Impact Evaluation Final Report*	August 2014	Residential lighting HOU; lamp wattage distributions
DNV GL	*Residential On-site Study: California Lighting and Appliance Saturation Survey (CLASS 2012)*	November 2014	Residential density data
Itron, Inc.	*2010-2012 WO017 Ex Ante Measure Cost Study Final Report*	May 2014	Full measure cost data
Itron, Inc.	*California Commercial Saturation Survey*	August 2014	Commercial density data; lamp wattage distributions
Itron, Inc.	*Nonresidential Downstream Lighting Impact Evaluation Report*	August 2014	Commercial lighting HOU

3.2.3 Key Updates and Outcomes in Stage 1

This section describes observations and outcomes from key updates to the MICS. The studies referenced are those listed in Table 3-6.

- DEER Weather-Dependent Measures: Generally, the updates to weather-dependent measures based on the DEER2014 Update data resulted in relatively minor changes to unit energy savings values.
- Commercial Lighting: DEER2014 Update affected equivalent full load hours for commercial lighting measures, as well as HVAC interactive effects due to the update of weather files. Market-weighted average wattages were updated based on Commercial Saturation Survey (CSS) data. The updates resulted in changes to unit energy savings and effective useful life values. Additional adjustments were made in response to updated HOU data in DEER2016.
- Residential CFLs: Hours of use and market-weighted average wattages were updated based on EM&V results and CA Lighting and Appliance Saturation Survey (CLASS) data. Measure costs were updated based on the Measure Cost Study. EUL was updated based on the CPUC's uncertain measure review.[24] The changes to the MICS characterization influenced the potential results because of the high contribution to overall energy savings of this measure.

[24] CPUC. *Ex Ante Update for ESPI Uncertain measures - Compact Fluorescent Lamps 30 Watts and Less.* May 2015.

» Measure Densities: With the updates to CSS and CLASS, measure densities in MICS were updated to reflect the most recent market saturation and survey data. Densities do not affect unit energy savings or measure costs, but they inform the model calibration and forecast procedures. Nearly all measures in Stage 1 received updated density values, and those values had an important role in the overall measure characterization for Stage 1.

3.2.4 MICS Database and Documentation

A complete MICS database is available through the CPUC website.[25] The database includes detailed descriptions and full characterizations of all measures in the 2015 PG Model. Users can download an Excel workbook that contains the following three tabs:

» Field Definitions: This tab includes a list of the data fields included in the MICS Master Build with a brief description of the fields.

» Measure Update Data Sources: This tab includes a table of the unique measures by sector and fuel type in the MICS Master Build. The table shows the Efficient Case, Base Case, and Code Case for each measure, as well as the relevant data sources used in the Stage 1 update.

» MICS Master Build: This tab includes the complete line-level detail for all sectors included in the 2015 PG Model.

3.3 Emerging Technologies

The Stage 1 update for Emerging Technologies (ETs) maintained the same measure list as the 2013 Study and focused on only updating the inputs to the 2015 PG Model where the Navigant team had better information or data availability.

For the purposes of this study, ETs are classified as meeting one or more of the following criteria:

» Not widely available in today's market but expected to be available in the next 1-3 years;

» Widely available but representing less than 5% of the existing market share; and/or

» Costs and/or performance are expected to improve in the future.

Appendix B.4 includes a full list of the ETs modeled, their descriptions, and key ET inputs. The table is organized by End Use category (e.g., Appliance Plug Loads, HVAC, etc.).

3.3.1 Overview of Updates

ETs were only examined for the Residential and Commercial sectors. These sectors are modeled using individual measures for specific applications.

The Navigant team relied on data from various sources to update each ET:

» The Navigant team extrapolated or used directly cost and performance data from DEER where possible. In some cases, some ETs had already been characterized in DEER since the 2013 Study.

[25] http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

For such cases, the Navigant team continued to call these measures ETs to be consistent with the last study (e.g. 0.98 AFUE Gas Furnace).

- » IOU workpapers and other case studies provided additional cost and performance data.
- » 2010 – 2012 EM&V studies[26] such as "Work Order 017 Ex Ante Measure Cost Study "provided more California-specific data.
- » In absence of any California-specific verified data, the Navigant team leveraged data from national studies published by the U.S. Department of Energy (DOE) and the Pacific Northwest National Lab (PNNL) and adjusted to California specific values based on regulatory and market conditions.
- » DOE standards and rulemaking review ensured the maximum technically feasible energy efficiency level for many measures and end uses remained same.
- » Energy Star's qualified products list and shipment data provided market saturation data.

While the measure categories remained same, their definitions were updated in some cases to reflect the market conditions more closely where we had better data.

- » LEDs were redefined based on CFL definitions update. LED definitions are linked to CFL definitions, which were updated based on 2010 – 2012 EM&V studies.
- » Residential Water heaters were updated from 0.77 Energy Factor (EF) to 0.82 EF due to the addition of 0.82 EF water heater measure to DEER. If a measure with same or higher efficiency than the corresponding ET efficiency was included in DEER since the 2013 Study, Navigant set the minimum efficiency of the ET to match the highest efficiency description in DEER for applicable measures.
- » Self-Contained Refrigerator measure was redefined to be 15% less than energy code due to redefinition of Energy Star products.
- » Dishwasher measure was redefined to be EF>1.0 compared to previous round, based on code and competing conventional energy efficient measure update.
- » Commercial Refrigeration Fiber Optic LED lighting measure was eliminated. LED display lights have become a standard practice for display case replacements.

Some ETs (along with some conventional technologies) are expected to decrease in cost over time. The Navigant team developed four cost reduction profiles that could apply to various ETs (and non-ETs) in the 2013 Study (see 2013 Study Appendix A). These cost reduction vectors were qualitatively assigned to each ET based on various market drivers that could drive the cost down. Navigant revised these cost reduction assignments based on the further market intelligence developed for the ET measures since the 2013 study (see Appendix B.4).

[26] *2010-2012 WO017 Ex Ante Measure Cost Study.*
2010-2012 WO013 Residential Lighting Process Evaluation and Market Characterization.
2010-2012 WO028 California Upstream and Residential Lighting Impact Evaluation.

3.3.2 Updates for LEDs

The Navigant team also updated data on the cost reduction and performance improvement profiles for LED technologies. LED costs have declined rapidly in recent years (a 50% reduction in market average price from 2011 to 2015) and are expected to continue to decrease in the foreseeable future. Meanwhile, LED efficacy has been increasing and is expected to increase over 40% from 2015 to 2024. This efficacy change will continue to decrease the wattage requirements of LEDs in the future. The PG Model reflects both of these trends.

LED efficacies were updated to reflect market average products and LED efficacies have dropped compared to the 2013 Study. Previous data[27] used in the 2013 Study represented the "best performers" in the market which was based on U.S. DOE technology targets and did not represent the majority of products in the market. New data[28] in Stage 1 represents the average performance and cost which are based on historical data for LEDs. Stage 1 also uses efficacy and cost data specific to LED applications (i.e. General Service and Directional), which allowed Navigant to map the efficacy data to each LED measure more precisely. The mapping of each LED measure to its definition and application can be found in Table B-2 in the Appendix B. LED costs were also updated to market average products based on the most recent DOE pricing study[29] conducted by PNNL.[30]

Then, these LED efficacies and prices were further adjusted to represent LEDs that meet the California Energy Commission's Voluntary Quality LED Lamp Specification[31]. The specifications are based on enhancements to the ENERGY STAR standard with a particular focus on improvements to the color temperature, consistency, and color rendering (with requirements for Color Rendering Index (CRI) greater than or equal to 90). The specification applies to screw-base and bi-pin A-lamp, flame-tip, globe, and spotlight lamps. After December 11, 2013, compliance with the specification for LED lamps became mandatory for IOU incentive program eligibility (this followed a one-year "transition period" that began when the specification came into effect on December 11, 2012). Additional details on the adjustments and data sources can be found in Appendix B.

Figure 3-2 and Figure 3-3 illustrate the resulting difference in LED efficacies used in both studies from 2013 to 2024. The small drop in the LED lamp efficacies from 2013 to 2014 shown in Figure 3-2 is due to the Voluntary Quality LED Lamp Specification going into effect in 2014. Figure 3-4 and Figure 3-5 illustrate the resulting difference in LED prices used in both studies from 2013 to 2024. Additional details on which LED measure are General Service and which are Directional can be found in Table B-2 in the Appendix B.

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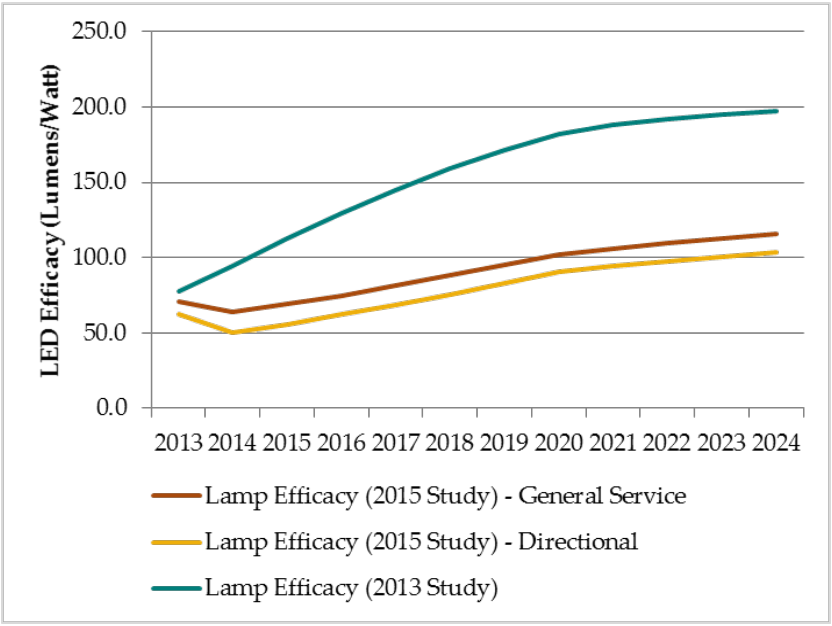
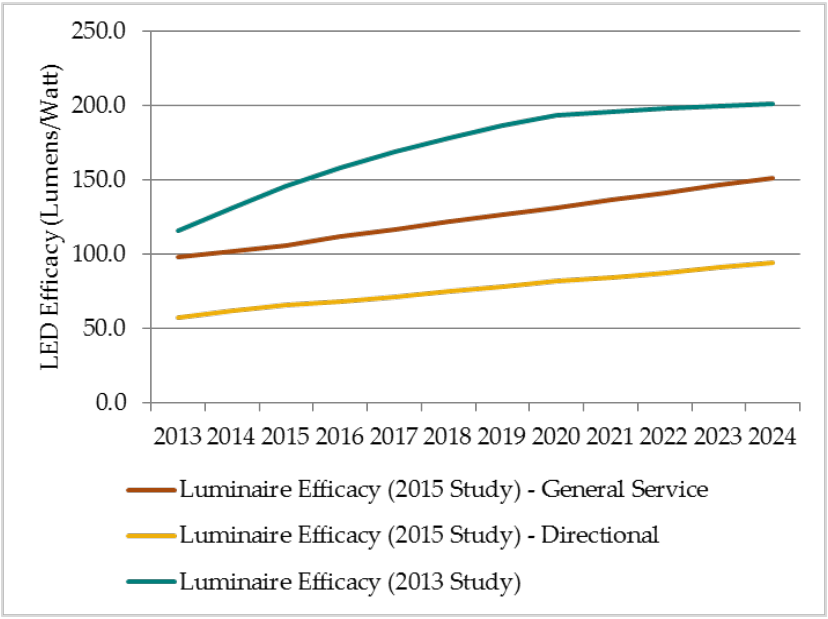
[27] Navigant. *Energy Savings Potential of Solid-State Lighting in General Illumination Applications.* Prepared for the U.S. Department of Energy, January 2012.
[28] Navigant. *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications.* Prepared for the U.S. Department of Energy, August 2014.
[29] Pacific Northwest National Laboratory. *Solid-State Lighting Pricing and Efficacy Trend Analysis for Utility Program Planning.* Prepared for the U.S. Department of Energy, October 2013.
[30] Although the CPUC Ex Ante Measure Cost Study examined some LED technologies, the information contained in the report was collected in 2013 and is already obsolete because of the rapid evolution of the LED market.
[31] http://www.energy.ca.gov/2012publications/CEC-400-2012-016/CEC-400-2012-016-SF.pdf

Figure 3-2: LED Technology Improvements (Lamps)



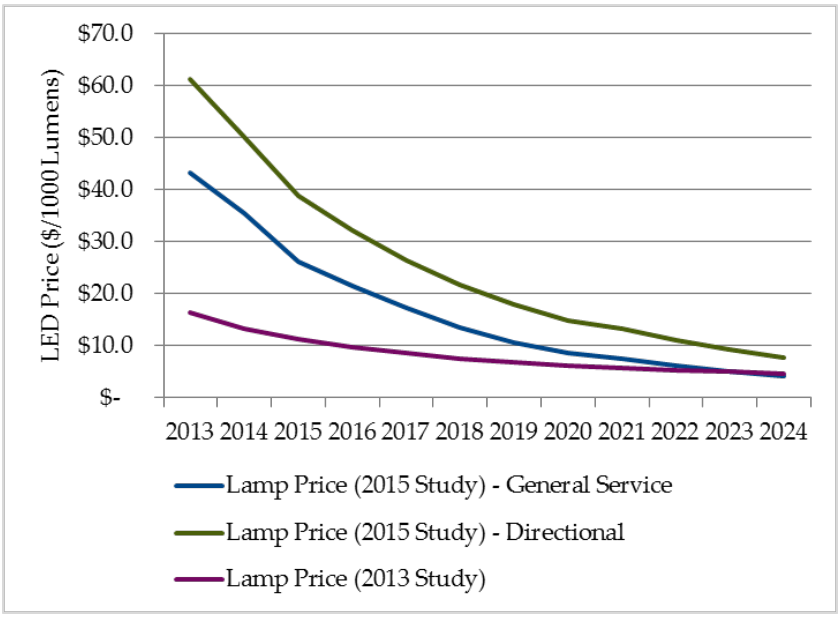
Source: Navigant team analysis 2015.

Figure 3-3: LED Technology Improvements (Luminaires)



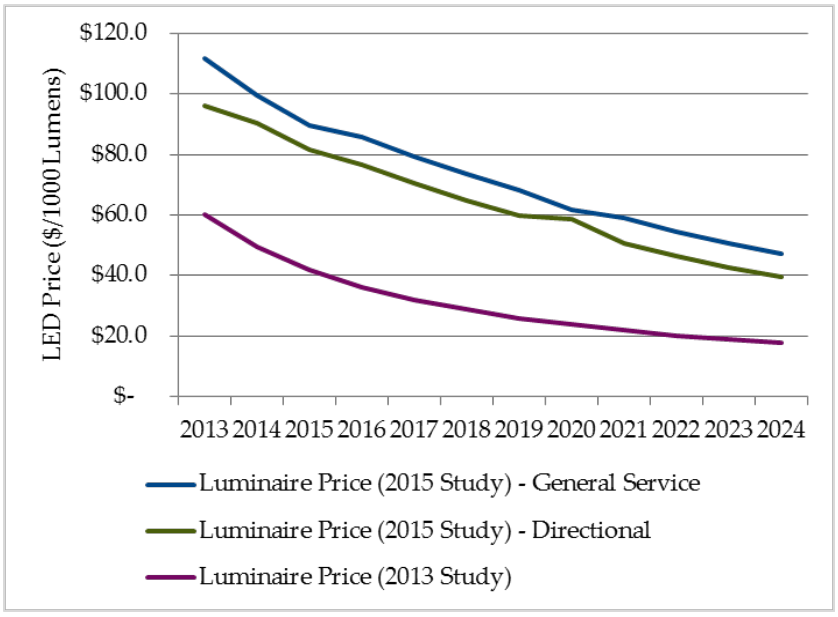
Source: Navigant team analysis 2015.

Figure 3-4: LED Cost Reduction Profiles (Lamps)



Source: Navigant team analysis 2015.

Figure 3-5: LED Cost Reduction Profiles (Luminaires)



Source: Navigant team analysis 2015.

3.3.3 Emerging Technology Risk Factor

In the 2013 Study, the Navigant team assigned a risk factor to each ET to account for the inherent uncertainty in the ability for ETs to produce reliable future savings. Actual future adoption of ETs will vary depending on technology. Some ETs may gain large customer acceptance, capture significant

market shares, and generate large savings, while others may falter achieving no market share and no savings. It is impossible to pre-determine which ETs will succeed and which will fail. The ET risk factor acts to de-rate the market adoption of each individual ET. The result is a total ET savings value that is representative of what can be expected of the group of ETs. In Stage 1, the Navigant team revised the risk factors based on the same qualitative metrics that were used previously which included market risk, technical risk, and data source risk. The framework for assigning the risk factor is shown in the 2013 Study.

Navigant's logic for revising the risk factors was based on the success of the measure meeting one or more of the following criteria since the 2013 Study:

- Has overcome some of the market barriers identified previously;
- Has established strong distribution channels;
- Has resolved remaining technology issues ; and/or
- Has produced evaluated energy savings that are equal to current (unevaluated) savings claims.

Appendix B.4 includes the final selected risk factors for each ET.

3.4 Agriculture, Industrial, Mining and Street-lighting (AIMS) Measure Characterization

For Stage 1 of the 2015 Study, Navigant built on the findings developed during the 2013 Study. In the 2013 study, Navigant developed approaches and detailed potential for each of the Agriculture, Industrial, Mining, and Street Lighting (AIMS) sectors.

3.4.1 Overview of AIMS in the 2013 PG Study

The Industrial sector uses a top-down approach to calculate industrial sector potential based on energy efficiency supply curves. This was accomplished by using a variety of data sources, including the Department of Energy's (DOE's) Industrial Assessment Center (IAC). The DOE-sponsored IAC database which provides thousands of industrial measure recommendations and installments based on engineering efficiency audits performed at thousands of industrial facilities. The team used approximately 15,000 energy efficiency recommendations from approximately 10,000 assessments IAC database completed from 2004 to 2012 as the core measure list.[32] The supply curves developed from these IAC measures were then adjusted and vetted using California specific data, including inputs from DEER, CPUC vetted workpapers, relevant inputs from the 2013 potential model Commercial sector inputs, and various sector specific California EM&V studies and market reports. A similar process was used to develop the Agriculture sector forecast. As a result, Navigant's Industrial and Agriculture sector potential forecasts are informed by 167 supply curves defining a specific combination of subsector, end-use, measure type, and fuel.

[32] The IAC database is substantially larger, containing more records than 10,000 assessments. However, the team screened the list for relevant measures and the 2013 Study Appendix provides more details the use of the IAC database.

Navigant's 2013 Study AIMS effort also established the framework to facilitate active and meaningful stakeholder interaction. Specifically, the 2013 Study effort for AIMS started the Industry Standard Practice (ISP) vetting exercise through a detailed ground-floor-level review of the individual codified IAC recommendations to determine their applicability in California. For example, the Navigant and stakeholder team considered established ISP, Title 20/24, local Air Resource Board (ARB, AB32, etc.)[33] positions, Occupational Safety and Health Administration (OSHA) requirements,[34] and other positions on maintenance processes from established IOU programs.[35] These activities accompanied other vetting exercises where potential estimates were reviewed through a comparative metrics exercise that leveraged IOU compliance filings,[36] industrial market characterization reports,[37] and other secondary studies on end-use-specific potentials and forecasts. Navigant conducted these reviews with representatives from the IOUs, the Ex Ante Team, as well as industry subject matter experts (SMEs).

Specific attention was paid to the Mining sector, where several highly developed ISP reports were available and were used to make significant reductions in initial energy effeciency potential forecasts for that sector, mostly addressing ISPs in the oilfield market. From these studies, Navigant developed measures and potential model inputs that were informed by oil and gas energy efficiency experts,[38] California statewide oil and gas extraction statistics,[39] and additional secondary sources. Inputs were also vetted with the Ex Ante Team to account for ISPs among major and minor oil extractors.

Finally, Navigant developed potential for the Street Lighting sector in the 2013 Study. This effort largely relied on IOU-supplied street lighting inventories that include detailed information on lamp counts, lamp types and technologies, lumens, and wattages. Navigant paired these comprehensive details with other secondary sources to estimate potential for the 2013 Study.

Additional details on the 2013 Study can be found at the CPUC's Energy Efficiency Potential and Goals Study webpage.[40]

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[33] Assembly Bill 32: Global Warming Solutions Act. Air Resources Board. Accessed June 20, 2014. http://www.arb.ca.gov/cc/ab32/ab32.htm

[34] OSHA. Hot Surfaces, 1910.261(k)(11). Accessed June 20, 2014. https://www.osha.gov/pls/oshaweb/owalink.query_links?src_doc_type=STANDARDS&src_unique_file=1910_0261&src_anchor_name=1910.261(k)(11)

[35] 2013-2014 Statewide Customized Retrofit Offering Procedures Manual for Business. Table 1.4.2 Summary of Ineligible Measures. Last Accessed June 20, 2014. http://www.aesc-inc.com/download/spc/2013SPCDocs/PGE/Customized%201.0%20Policy.pdf

[36] 2013-14 Energy Division Investor-owned Utilities Compliance Filing Reviews. Last Accessed June 20, 2014. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/2013-14+IOU+Compliance+Filing+Reviews.htm

[37] KEMA. Industrial Sectors Market Characterization. Metalworking Industry. Last Accessed June 20, 2014. http://calmac.org/publications/Final_metalworking_market_characterization_report.pdf

[38] Navigant team conference meeting with GEP staff via telephone. Global Energy Partners, an EnerNOC Company. (2012). Meeting on November 30, 2012.

[39] CA Dept. of Conservation. 2009 Annual Report of the State Oil and Gas Supervisor. Last accessed: March 2015. ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2009/PR06_Annual_2009.pdf

[40] CPUC. Energy Efficiency Potential and Goals. Last accessed April 2015. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

3.4.2 2015 Study: Building on the 2013 Study

Stage 1 continued to use the same methodology as the 2013 Study; the team focused on updating inputs. Navigant completed several detailed data gathering and analyses activities to further develop the 2013 AIMS model framework, including the following critical tasks:

- Incorporated recently-completed and published ISP studies that have been reviewed, vetted, and deemed eligible for consideration by the CPUC. Navigant also relied on CPUC guidance and input to establish the list of ISP studies to consider for Stage 1.
- Reviewed the IAC database for recent updates and additions.
- Reviewed other critical data sources for any significant updates. These included the California Integrated Energy Policy Report (IEPR) consumption and retail rate forecast data[41] and sector-specific data such as IOU street lighting inventories.
- Held formal and informal meetings and discussions with stakeholders (e.g., Demand Analysis Working Group [DAWG] Webinar on AIMS Updates). These meetings informed the Stage 1 efforts, but also identified critical issues for consideration in advance of the Stage 2 efforts.
- Reviewed the process by which ISPs are developed and used within the inputs for Industrial, Agriculture, and Mining. This included reviewing secondary sources, IOU-supplied data, and exploring alternative approaches to accounting for ISPs. These topics will be further reviewed during Stage 2.

The following sections provide additional overview of the activities carried out for each AIMS sector for the Stage 1 update. Appendix C provides further details and analyses findings.

3.4.2.1 Industrial

The Navigant team considered the full range of inputs for the Industrial sector to determine where new data sources exist and where existing data sources received significant updates since the 2013 Study.

Stage 1 updates and analysis activities included a review of recently-released ISP studies from the CPUC. Navigant mapped ISPs into the potential inputs based on the studies' relationships to the measures and end-uses, sub-sectors, and in consideration of measure equipment densities (i.e., measure saturation/density, sub-sector applicability, etc.). These ISP-related activities updated a selection of measure de-ratings previously estimated in 2013. This review process also vetted the measures (defined as assessment recommendation codes [ARCs] sourced from the Industrial Assessment Center [IAC]). This vetting exercise supplemented similar reviews completed for the 2013 Study and confirmed the inputs and de-ratings established in 2013.

The team also reviewed other sources for updates to the inputs. Those include the IAC database, the California IEPR, the California Quarterly Fuel and Energy Report (QFER), and IOU planning documents such as IOU Compliance filings. Appendix C.1 notes where updates occurred.

[41] CEC. California Energy Demand 2015-2025 Final Forecast Mid-Case Final Baseline Demand Forecast Forms. Last accessed: March 2015.
http://www.energy.ca.gov/2014_energypolicy/documents/demand_forecast_sf/Mid_Case/

3.4.2.2 Agriculture

Similar to the Industrial sector, the Navigant team considered the full range of inputs and sources for the Agriculture sector to determine where new data sources exist and where existing data sources received significant updates since the 2013 Study. The Agriculture sector relies on IAC, QFER, and IEPR data. DEER and the Commercial sector Study effort also inform the Agriculture sector.

The Agriculture sector methodology is similar to the Industrial sector. The Agriculture inputs also rely on the updated Industrial sector measure de-ratings in order to reflect ISPs, program eligibility considerations, and other constraints that prevent Agriculture programs from claiming certain savings.

Navigant also accounted for the impacts of drought conditions after it correlated energy consumption increases with drought years. For example, during drought conditions water tables are lower and more energy is required of irrigation pumps to lift water to the surface. The team normalized forecast data to represent typical energy consumption in non-drought years. This was critical given that the PG Model estimates potential as a percent of energy consumption.

Finally, the other sources reviewed for the Industrial sector were also reviewed for the Agriculture sector and updates are noted in Appendix C.2.

3.4.2.3 Mining

Following the Industrial and Agriculture sectors, Navigant conducted a similar review of inputs and sources for the Mining sector. However, unlike the Industrial and Agriculture sectors, the Mining sector relies on an approach more similar to the Residential and Commercial sectors. Inputs are developed from the bottom up and define specific measures instead of more broadly defined end-uses.

Navigant determined that there are no significant updates for measure-specific parameters such as baseline and measure level efficiencies or equipment costs. However, Navigant reviewed the range of sources to both vet the 2013 Study inputs as well as identify any new or updated sources to consider that apply to the market more generally. For example, Navigant observed increasing trends in enhanced oil recovery (EOR) techniques. This relates to injecting pumps and process steam boilers where, over time, more energy in the form of injected water and steam are needed to extract oil that is becoming harder to reach. Stage 1 inputs were updated to reflect this trend.

3.4.2.4 Street Lighting

Navigant also reviewed the inputs for the Street Lighting sector as part of the Stage 1 effort. The 2015 Study generally maintains the methodology developed for the 2013 Study. Namely, Navigant used the IOU-supplied inventories and consumption data from the 2013 Study to estimate baseline and energy efficient measures for customer owned and IOU owned lamps. Navigant also requested and received

2015 street lighting inventories and consumption data from the IOUs and leveraged this data for vetting the inputs.

The most significant change to the inputs includes accounting for forecasted improvements in LED efficacies. The 2013 Study only accounted for forecasted LED cost reductions.

Finally, similar to the 2013 Study approach, the Stage 1 results reflect lamps owned by both customers and IOUs. However, Table 3-7 and Table 3-8 show owner-related metrics so that potential for a given group can be estimated separately.

Table 3-7: Percentage of Baseline and Efficient Street Lamps by Utility

Year	Efficient Lamps (%)*			Baseline lamps (%)**		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
2013	4%	1%	23%	96%	99%	77%
2015	26%	1%	31%	74%	99%	69%

**LED Lamps*
***Non-LED Lamps*
Source: Navigant team analysis of IOU-provided lamp inventories (2015)

Table 3-8: Percentage of Customer Owned and Utility Owned Street Lamps

Year	Customer Owned (%)			Utility Owned (%)		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
2013	74%	17%	81%	26%	83%	19%
2015	76%	15%	81%	24%	85%	19%

Source: Navigant team analysis of IOU-provided lamp inventories (2015)

3.5 Whole Building Initiatives

Whole-building initiatives aim to deliver savings to residential and commercial customers as a group of multiple efficiency measures that are all installed at the same time. Similar to the 2013 Study, Stage 1 of the 2015 Study includes the same whole-building initiatives. Stage 1 data updates are indicated in Table 3-9 below.

Table 3-9: Whole-Building Measures Stage 1 Updates

Whole-Building Measure Name	Stage 1 Data Updates
Commercial New Construction Level 1	Same as 2013 Study
Commercial New Construction Level 2	Same as 2013 Study
Commercial New Construction Level 3	Same as 2013 Study
Commercial New Construction ZNE	Updated data
Commercial Renovation Level 1 – 14% Savings	Updated data
Commercial Renovation Level 2 – 28% savings	Updated data
Residential New Construction Level 1	Same as 2013 Study
Residential New Construction Level 2	Same as 2013 Study
Residential New Construction Level 3	Same as 2013 Study
Residential New Construction ZNE	Updated data
Residential Renovation Energy Upgrade CA - Basic Path (MF only)	Updated data
Residential Renovation Energy Upgrade CA - Flex Path (SF Only)	Updated data
Residential Renovation Energy Upgrade CA - Advanced Path (SF Only)	Updated data

Source: Navigant team analysis, 2015

In the 2013 Study, the Navigant team developed estimates of energy savings and costs for each whole-building measure listed in Table 3-9 and described in Appendix E of the 2013 Study report. The following sections discuss the key updates made to date in the 2015 Study. The final values for savings, cost, measure life, and other key model inputs can be found in the MICS spreadsheet.

3.5.1 Commercial and Residential New Construction ZNE

Table 3-10 provides the Commercial and Residential New Construction ZNE updated sources for Stage 1. PG&E is in the process of conducting a ZNE study, results of which will be incorporated into Stage 2.

In general, baseline construction costs increased slightly since the 2013 Study, which is reflective of the recovery of the construction industry over the last few years. For single family homes, baseline electricity, electric demand and natural gas consumption (kWh/sf, kW/sf and therms/sf) decreased slightly. For multi-family homes, baseline electricity consumption (kWh/sf) increased by about 40 percent. Baseline electric demand (kW/sf) and natural gas demand (therms/sf) for multi-family homes both decreased.

Table 3-10: Commercial and Residential New Construction ZNE Data Updates

Data Items	Data Source
Baseline construction costs	Reed Construction Data Inc., RS Means Square Foot Estimator: http://www.rsmeansonline.com
2013 Title 24 Residential Code-Baseline Energy Consumption	Single and multi-family electricity, electric demand and natural gas consumption updated by California Energy Commission, CBECC-Res 2013 Std. Design Results, January, 2015.

3.5.2 Commercial Renovation Level 1 and Level 2

In the 2013 Study, Commercial Renovation Level 1 and Level 2 bundles were developed by the Navigant team. Data was developed for each IOU territory and each building type. A "bundle" of measures was assembled for each initiative that represents the weighted average installation of measures by a typical participant. In assembling these bundles, only measures from the MICS were eligible for inclusion in these bundles.[42] Each bundle was developed to include gas and electric measures, assuming no overlap between the two fuel types.

Stage 1 updated the 2013 Study bundles to reflect the latest Commercial MICS measure data, without altering the specific individual measures included in the bundles. The specific measures included in the bundles will be evaluated in Stage 2 of the 2015 Study.

3.5.3 Residential Renovation Energy Upgrade California

For the Residential Renovation Energy Upgrade California (EUC) measures, Navigant collaborated with DNV GL who conducted the *2010-2012 Whole House Retrofit Impact Evaluation*.[43] The EUC evaluation study and the EUC program tracking data detailed in Table 3-11 were used to provided updated information for Stage 1.

Table 3-11: Commercial Retrofit Level 1 and Level 2 Data Updates

Data Source Name	Data Source
Whole House Retrofit Impact Evaluation	CALMAC ID: CPU0093.01 http://www.calmac.org/publications/CPUC_WO46_Final_Report.pdf
CPUC 2013-2014 EUC Program Tracking Data	EDCentralServer.com, alltracking1314q7_wroadmap.sas7bdat

Stage 1 modeled the same three measure bundles as the 2013 Study which include: Basic Path, Flex Path and Advanced Path. Compared to the 2013 Study, Stage 1 data resulted in a decrease in electricity, demand and natural gas savings and an increase in the energy efficiency material cost.

[42] See 2013 Study Appendix Section E.1 for additional context on the sources of data for measures eligible for the bundles.

[43] DNV GL – Energy, 2014. *Whole House Retrofit Impact Evaluation. Evaluation of Energy Upgrade California Programs.* Work Order 46. Prepared for the California Public Utility Commission, Energy Division. Final Report: September 9, 2014. CALMAC ID: CPU0093.01, http://www.calmac.org/publications/CPUC_WO46_Final_Report.pdf

- **Basic Path:** Whole House Retrofit Impact Evaluation study did not include multifamily homes, so the data for calculating Basic Path savings remained the same as the 2013 Study.
- **Flex Path:** The Flex Path savings were developed from the impact evaluation report, but in 2010-12 most retrofits were either Advanced or Basic. The Flex path savings were developed by assuming a weighted average of 2/3 Advanced and 1/3 Basic to make up Flex. The reasoning behind this assumed weighting was the measures that were installed with high frequency in 2010-12 Advanced were similar to the Flex options in roughly two-thirds of the cases, while the remaining third of the Flex options resembled the Basic path.
- **Advanced Path:** Whole house Retrofit Impact Evaluation data was used to update the electricity, electric demand, natural gas savings and energy efficiency cost data.

The measure saturation/density is another change worth noting. The measure saturations/densities were determined based on utility customer population data from Residential Appliance Saturation Study (RASS)[44] and Energy Information Administration (EIA)[45] records, final tracking data used for the impact analysis covering program years 2010-12, and the latest available tracking data for program years 2013-14. The data for the impact evaluation specifically checked for homes that had gas and electric or gas only and avoided double-counting customers. The available data for 2013-14 could not be fully de-duplicated in a similar manner, so the data was used with some slight adjustments based on the ratio of tracked records to unique customers from the impact evaluation. Between the 2013 Study and the 2015 Study, the efficienct technology density (number of EUC program participants/existing building stock) increased as additonal households particpated in the program.

Concern exists that the cost data reported for the program does not just include energy upgrade measures costs but general project retrofit costs that do not all impact energy savings. Additional efforts are already being made by the study team to further evaluate the true incremental costs for a EUC program participant.

3.6 Codes and Standards

Codes and Standards (C&S) impacts on energy efficiency potential are modeled two ways:

- C&S reduces the Unit Energy Savings (UES) for IOU rebated measures, thus decreasing the savings claimable by IOU programs
- IOUs can claim a portion of savings from C&S that come into effect through the IOU C&S advocacy programs.

[44] RASS 2009. Volume 1: Methodology. Table 2-2A-B Individually Metered Sample Design. http://websafe.kemainc.com/rass2009/Uploads/2009_RASS_Volume%201_%20FINAL_101310.pdf
45 RECS Survey Data 2009. Household Demographics by Year of Construction. Table HC9.3 Household Demographics of U.S. Homes, By Year of Construction, 2009. http://www.eia.gov/consumption/residential/data/2009/#undefined

3.6.1 Impacts of C&S on IOU Programs

As new C&S come into effect, the code basis above which IOUs may claim energy savings changes. As high efficiency C&S come into effect, code baselines increase and claimable unit energy savings decrease. The impact of C&S on UES over time is represented by a time series set of multipliers. The time series multipliers are referred to as the "C&S vectors".

A "vector" of impact percentages was developed for each incentive program measure to capture the impact of C&S in each year. C&S impact vectors are used as the input to the PG Model to assess the total impact of new state and federal standards to potentials of incentive programs. C&S vectors are multiplied by the UES values to create a time series of above-code, claimable UES for use in the model. For incentive program measures not affected by any new standards, values of the impact percentages are 100%. As new C&S come into effect, impact percentages below 100% are derived. In some cases impact percentages can drop to 0% (if the new code is equal to or surpasses the efficiency level of the measure). The methodology for determining impact percentages remains unchanged from the 2013 study.

MICS unit energy savings values in Stage 1 represent the unit energy savings of a measure in 2015. Thus, code vectors are built such that vectors equal 100% in 2015 and decline in value over time as new C&S come into effect. In some special cases the C&S vector is less than 100% in 2015 (if the measure in MICS was not updated to reflect current codes in 2015).

Updates to the MICS data as well as the passing of new C&S required updates to the C&S vectors in Stage 1. New C&S considered in this study include 2015 and 2018 Federal Residential Clothes Washers Energy Conservation Standards[46] and 2018 Federal General Service Fluorescent Lamps Energy Conservation Standards[47].

The C&S impact vectors for each measure are listed in Appendix D.

3.6.2 Net IOU Attributable C&S Savings

The CPUC 's 2010-12 C&S impact evaluation study[48] used the Integrated Standards Savings Model (ISSM)[49] developed by CADMUS and DNV GL to estimate net IOU attributable C&S savings. For C&S that were modeled in ISSM, the 2015 PG Model uses ISSM data. For all other C&S, the 2015 PG Model uses data from the 2013 Potential and Goals Study[50]. The 2013 model leveraged data from the 2006-08 impact evaluation. Table 3-12 lists the scope of each of the past to C&S evaluation studies in terms of the number and types of codes and standards evaluated. The 2015 potential adds new data on 40 codes and standards from the 10-12 evaluation; this is data that was not available in the 2013 study. A full list of

[46] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39
[47] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/70
[48] Cadmus, Energy Services Division and DNV GL. *Statewide Codes and Standards Program Impact Evaluation Report For Program Years 2010-2012.* August 2014.
[49] Cadmus, Energy Services Division and DNV GL. *Integrated Standards Savings Model (ISSM).* Last accessed: January 2015.
[50] Navigant Consulting, Inc. *2013 California Energy Efficiency Potential and Goals Study*. February 2014.

the modeled C&S, their compliance rates, effective dates, and policy status (on the books, possible, or expected) are listed in Appendix D.

Table 3-12: C&S Groups and Evaluation Scope

IOU C&S Group	Number and Type of Codes and Standards	Evaluation Scope
2005 Title 20	22 appliance standards	2006-2008 PY Evaluation
2006-2009 Title 20	11 appliance standards	2010-2012 PY Evaluation
Federal	7 appliance standards	2010-2012 PY Evaluation
2005 Title 24	19 building codes	2006-2008 PY Evaluation
2008 Title 24	22 building codes	2010-2012 PY Evaluation

Source: Cadmus, Energy Services Division and DNV GL. Statewide Codes and Standards Program Impact Evaluation Report for Program Years 2010-2012. August 2014.

The 2013 study made use of "realization rates" in forecasting savings from unevaluated C&S. These realization rates were determined as part of the 2011 Potential and Goals Study. The realization rates were only applied to unevaluated C&S and were based on evaluated C&S (from the 2006-08 evaluation period). Stage 1 removes the use of realization rates (setting them to 100%) as the ISSM used in the 2010-12 evaluation does not include realization rates for unevaluated C&S. This allows the potential study to better align with EM&V data.

As previously noted in section 2.2, the 2015 study uses no layering when analyzing net IOU attributable C&S savings. This is change in methodology relative to the 2013 study.

3.7 Behavior Energy Efficiency

Updates to the behavior model used best available data for existing behavior programs, while considering the difference between operational, or usage-based, and equipment savings. For both residential and non-residential behavior, the team used the same methodology and parameters as the 2013 study. This included using building operator certification (BOC) and home energy report (HER) programs as the representative programs. The team reviewed over 75 sources (listed in Appendix E. , as well as stakeholder comments. Table 3-13 summarizes the parameters for each sector, as well as the key sources driving the Stage 1 updates for each parameter.

Table 3-13: Summary of Behavior Model Parameters and Stage 1 Update Key Sources

Non-Residential		Residential	
Parameter	Key Source(s)	Parameter	Key Source(s)
% of floor space impacted	Assessment of commercial building stock data	Participation rates	CPUC data on current and planned CA IOU participation rates (HER programs)
Usage-based savings per 1,000 square feet	Research Into Action and Energy Market Innovations, *Summary Of Building Operator Certification Program Evaluations*, November 2011; and others	Savings rates (kWh and therms) per household	Most recent available CA IOU HER program evaluations (except SCG)
		Portion of household savings from usage-based behavior	Review of 21 sources addressing the topic (nationwide)

3.7.1 Non-Residential Behavior Model Updates

For the Stage 1 update the team reviewed recent studies evaluating BOC programs and also revisited studies reviewed for the 2013 model.[51] Some of the recent studies were explicit about energy savings and reductions in energy densities associated with changes in operating practices in contrast to savings that result from equipment upgrades, while other reports didn't distinguish between which of these two activities generated savings.

The aggregate impact of this research resulted in the team increasing the savings in electricity associated with changes in operating practices from 41 to 58 kWh per thousand square feet of participating building space. This was based largely on a 2011 Energy Market Innovations, Inc and Research into Action report which clearly analyzed and documented the energy savings associated with changes in operating practices that result from BOC programs.[52] The team did not find a compelling reason to increase natural gas savings associated with building operator training.

In addition to increasing the savings per unit of building area, the team also adjusted the forecast of market penetration of operator training to suggest that BOC practices will reach higher levels of saturation within the study timeframe. The increased level of participation will be driven by those organizations that operate portfolios of buildings, such as city, county, state and federal governments, and institutional organizations like the primary and secondary education sectors, and operators of large commercial buildings portfolios, such as real estate investment trusts. For example, a 2014 study

[51] All four IOUs began offering BOC training in 2002. Research Into Action, *Evaluation of the 2002 Statewide Building Operator Certification And Training Program*, November 2003, Pacific Gas & Electric. BOC was introduced in the 2011 potential study as being the most direct estimate of 'behavioral savings', however these types of program do not represent the universe of programs that achieve operational savings.

[52] Research Into Action, BOC-Expansion Initiative Market Progress Evaluation Report #1, April 2014 , Northwest Energy Efficiency Alliance

indicated that approximately 40% of BOC training involves staff associated with government and institutional facilities. [53] The BOC saturation estimates used in the 2015 update forecast that by 2026 training will impact roughly 3.5% of commercial building space annually, with cumulative training impacting roughly 23% of commercial space.

Based on a recent report recommending 5 years, the team did not revise its 2013 model assumption (also 5 years) on persistence of training impacts.[54] Lastly, the team did not increase the gas savings estimates because there wasn't compelling research to support such a change. Table 3-14 summarizes the non-residential inputs for the 2013 and 2015 models.

Table 3-14: Non-Residential Inputs for 2013 and 2015 Studies

Non-Residential Inputs	2013 Study	2015 Study
Portion to usage-based behavior (kWh/1,000 sq. ft.)	41	58
Portion to usage-based behavior (therms/1,000 sq. ft.)	5.6	5.6
2015% of commercial floor space impacted	0.95%	1.00%
2026% of commercial floor space impacted	3.00%	3.45%

Source: Navigant team analysis, 2015

3.7.2 Residential Model Updates

For the 2015 residential behavior model, the team updated the three model parameters included within the 2013 model based on data from each IOU's latest evaluation reports, correspondence with the CPUC as well as review of EM&V reports for similar programs (listed in Appendix E. . Below we summarize each of these parameters; 1) HER program participation, 2) HER savings results from billing analyses, and 3) an assessment of HER savings allocated to equipment and behavior-based usage.

1. **HER Program Participation:** The team updated HER program participation rates to reflect prior, current and anticipated HER program participation provided by the IOUs and the CPUC.[55] While participation in the HER programs may change over time (either due to attrition from program opt-outs or moving out of the service territory, or due to changes to program implementation such as adding new cohorts), there is no good way to forecast that specific change in participation beyond discussion with the IOUs. As such, we chose to apply the participation amounts at a constant rate based on conversations with the IOUs. However, the behavioral model uses IOU forecasted populations that increase over time (from 2016-2024). As

[53] Impact Evaluation of the California Statewide Building Operator Certification Program, CALMAC Study ID: CPU0069.01. Prepared for the California Public Utilities Commission by Opinion Dynamics Corporation, February 2014. Table 67. PY2010-2012 BOC Participants by Market

[54] Research Into Action, *BOC-Expansion Initiative Market Progress Evaluation Report #1*, April 2014 , Northwest Energy Efficiency Alliance

[55] CPUC. *SW EA Monthly Metrics Report All IOUs Oct 2014_111314.xlsx*. January 2014; CPUC. *Email from Valerie Richardson*. February 2015. Emails from each IOU in April 2015.

such, while we applied a constant participation rate as a percentage, the rate is multiplied by an increasing future population so the absolute number of actual HER participants increases over time.

2. **HER Percent Savings per Household from Billing Analysis:** The team applied per-household adjusted savings rates for each IOU from their respective 2013 program evaluation reports. For PG&E, we calculated a weighted average using each individual wave treatment participation numbers and per household savings percentages to derive a single value that could be applied across the full treatment population.[56] For SCE, we applied the average percent savings per household as reported in the latest evaluation report.[57] The gas savings rate for SCG is based on the Advanced Meter Semi-Annual Report from August 2014.[58] For SDG&E, we applied the average percent savings per household as reported in the latest evaluation report.[59]
3. **Allocation of Equipment or Behavior based savings:** While billing analyses do a good job of determining a per-household savings rate, the data cannot show what percent of the savings come from installation of energy efficient equipment or changes in behavior. To account for this, previous iterations of the PG study estimated the percent of the HER program savings assumed to be from behavior change to ensure that the model appropriately counted only behavior based changes.[60] Upon review of the recent EM&V studies cited in Appendix E. , we determined that this factor is no longer needed for two reasons: 1) utility rebated equipment is already discounted from the evaluated savings estimates percent via double counting analyses[61], and 2) program evaluations establish that the remaining savings, which consists of usage based and non-utility rebated equipment based savings, is the true influence of the behavior program.

As a result of these updates, the model increased the estimate of electricity and gas savings associated with residential behavioral programs. The increases are primarily due to the increase in participation rates and the removal of the equipment vs. behavior calculation. Table 3-15 summarized the residential inputs for the 2013 and 2015 models.

[56] The PG&E EM&V report does not provide an aggregate percent savings per household value, we leveraged information from the following reports and correspondence with DNV-GL to derive this value. 2013 PG&E Home Energy Reports Program . n/a. DNV-GL. 2015; 2013 PG&E Home Energy Reports Program. n/a. NEXANT. 2015

[57] SCE's Home Energy Report Program Savings Assessment: Ex-Post Evaluation Results, Program Year 2013, Final Report. Applied Energy Group, October, 2014: CALMAC Study ID: SCE0365.01, pp. v.

[58] The current SCE behavior program is implemented as part of SCE's Advanced Metering Infrastructure deployment. As such, Navigant based the SCG savings estimates on the August 2014 Advanced Metering Semi-Annual report provided by SCE staff. Nexant, Evaluation of Southern California Gas Company's 2013-2014 Conservation Campaign Submitted to Southern California Gas Company, August 29, 2014.

[59] SDG&E Home Energy Reports Program, 2013 Impact Evaluation, ED Res 3.3, DNV-GL, October 2014, pp. 2.

[60] See the 2013 study for more details.

[61] Double-counting analysis identifies and removes any energy savings that occurred from HER participants participating in both an IOU-rebated program and HER program.

Table 3-15: Residential Inputs for 2013 and 2015 Studies

Residential Inputs	PG&E	SCE	SCG	SDG&E
Participation Rates 2014-2026 -- % of Residential Population				
Assumes constant rates of participation, applied to shifting number of customers in each IOU territory by year.				
2013 Study	5.00%	5.00%	5.00%	5.00%
2015 Study	22.62%	4.96%	0.82%	16.00%
kWh Savings Rates 2014-2026 -- % per Household				
Assumes constant savings rates.				
2013 Study	1.80%	1.80%	n/a	1.50%
2015 Study	1.08%	1.40%	n/a	2.60%
Therm Savings Rates 2014-2026 -- % per Household				
Assumes constant savings rates.				
2013 Study	1.30%	n/a	1.30%	0.90%
2015 Study	0.61%	n/a	1.30%	2.00%
Behavior vs. Equipment				
2013 Study	67.00%	67.00%	67.00%	67.00%
2015 Study	100%	100%	100%	100%

Source: Navigant team analysis, 2015

3.8 Low Income Programs

The Navigant team reviewed the low income sector forecast and model inputs with staff from the CPUC and the IOUs determined additional edits relative to the 2013 study were necessary to align with recent data. The two key inputs reviewed and updated for the low income sector were 1) unit energy savings (savings per participant) and 2) forecasted number of participants.

The average savings per household as reported in the Energy Savings Assistance (ESA) Annual Reports provides the most accurate and transparent approach to defining unit energy savings (UES) for the low income segment. The team analyzed these reports focusing on reported savings from 2011 through 2014. Table 3-16 provides the final UES values used in the 2015 model and compares the value to that used in the 2013 study. The final values used in the 2015 study are the average of reported savings per participant from 2011 to 2014. SCE KWh savings increased significantly while PG&E and SDG&E decreased. All estimates for demand savings per participant decreased relative to the 2013 study. Gas savings per participant decreased for PG&E and SDG&E while increasing for SCG.

Table 3-16: 2015 Potential Model UES Input Assumptions – Average Savings per Treated Household

Utility	2013 Model	2015 Model
KWh/Participant		
PG&E	391	349
SCE	286	378
SDG&E	397	333
SCG	-	-
KW/Participant		
PG&E	0.24	0.08
SCE	0.29	0.14
SDG&E	0.23	0.03
SCG	-	-
Therms/Participant		
PG&E	20	15
SCE	-	-
SDG&E	21	17
SCG	20	27

Source: Navigant team analysis of ESA Annual Reports

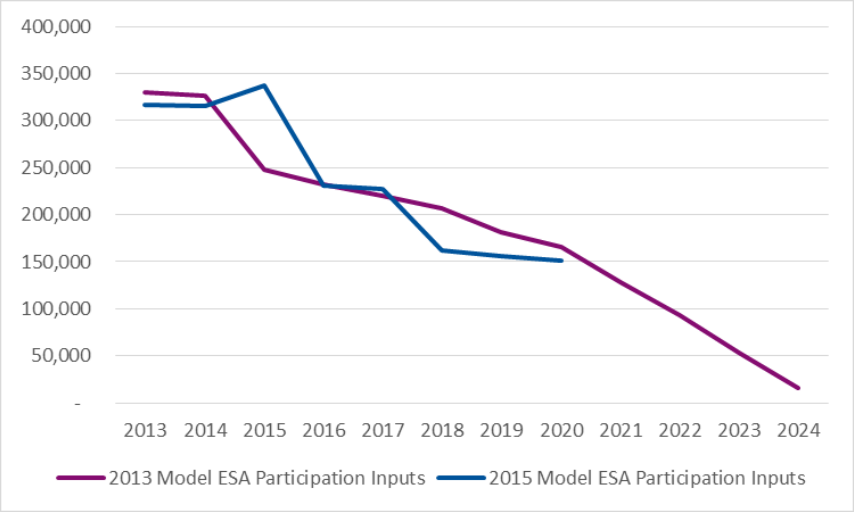
The Navigant team also updated the model's low income program participation forecasts to align more closely with IOU participations forecasts and with current CPUC policy stating that all eligible and willing ESA program candidates would be served by 2020. Table 3-17 provides the recommended participations forecasts for 2015 through 2020, while Figure 3-6 provides a comparison of the final 2015 model participation forecasts with forecasts used the and 2013 potential models. The final 2015 forecasts does not extend beyond 2020 because CPUC policy beyond that date is currently uncertain. The forecasts for participation in the 2016 to 2020 period are relatively consistent though lower than the 2013 study assumptions.

Table 3-17: Low Income Program Participation and Forecast by Utility[62]

Year	Forecast of Total Homes Treated				
	Total	PG&E	SCE	SDG&E	SCG
2015	337,645	119,940	87,389	20,316	110,000
2016	231,316	47,000	54,000	20,316	110,000
2017	227,316	43,000	54,000	20,316	110,000
2018	162,316	38,000	54,000	20,316	50,000
2019	155,816	31,500	54,000	20,316	50,000
2020	150,876	26,560	54,000	20,316	50,000

Source: Navigant team analysis of ESA Annual Reports

Figure 3-6: Comparison of ESA Participation Forecasts



Source: Navigant team analysis of ESA Annual Reports

3.9 Energy Efficiency Financing

The CPUC has recognized financing as an energy efficiency resource program[63]. In the 2013 Study, Navigant developed a new approach to estimate the savings impact from financing; the approach considers financing as a mechanism influencing customer choices by reducing market barriers such as hassle factor, liquidity constraint, and high up front cost[64].

[62] 2015 – 2020 participation forecasts are net of any retreatment or add-back assumptions

[63] CPUC Decision 12-05-2015, May 8, 2012 and Decision Approving 2013-14 Energy Efficiency Programs and Budgets, October 9, 2012

[64] Gillingham, Newell, and Palmer. (2009). "Energy Efficiency Economics and Policy." *Resources for the Future*, 2009. Available at: http://www.rff.org/documents/RFF-DP-09-13.pdf

The 2015 Study follows the same methodology and analytical approach as the 2013 Study. We leveraged the CPUC led Statewide Finance Baseline Residential study[65] and California-specific business credit score data to update residential and commercial sector market characteristics in the 2015 Study. The key areas of data updates include:

- **Eligible population**: Navigant identified residential and non-residential population eligibility as a key area of data update for Stage 1. Navigant conducted additional research on California specific residential and commercial customer credit score distribution. The CPUC led Statewide Finance Baseline Residential study obtained over 11,000 consumer credit data points from Experian. Consistent with the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) financing pilot program customer credit score minimum requirement, Navigant assumes residential customers with FICO score above 580 are eligible for financing. Similarly, Navigant collected 10,000 business credit score data points from Experian and assumed that businesses with low to medium credit risks are eligible for financing.
- **Interest rates**: The California Statewide Finance Baseline Residential Study includes a mystery borrower analysis, the study collected over 400 interest rate quotes from California banks and credit unions. Navigant updated the market interest rate assumption in the PG model accordingly.
- **Implied Discount Rate reduction**: Based on the preliminary findings from the Statewide Finance Baseline Residential study, the percent of residential customers citing upfront cost as a market barrier is higher than Navigant's previous estimation. Navigant has made adjustments to the implied discount rate reduction for the single family and multi-family sectors.

Table 3-18 summarizes the data updates for Stage 1.

Table 3-18: Summary of Financing Model Data Update

Input	2013 Study Value	2015 Study Value	2015 Study Source
Single Family Sector Interest Rate	9%	8%	Mystery Borrower Analysis, PY2013-2014 California Statewide Finance Baseline Residential Study under Work Order ED_O_FIN3
Single Family Eligible Population	63%	98%	Experian Consumer Credit Data, access date: Nov 19, 2014
Commercial Eligible Population	20%	77%	Experian Business Credit Data, access date: Mar 2, 2015
Single Family Sector Implied Discount Rate Reduction*	11%	14%	Residential Baseline Survey, PY2013-2014 California Statewide Finance Baseline Residential Study under Work Order ED_O_FIN3
Multi-Family Implied Discount Rate Reduction	13%	20%	Residential Baseline Survey, PY2013-2014 California Statewide Finance Baseline Residential Study under Work Order ED_O_FIN3

[65] Work performed under Work Order ED_O_FIN3

As shown in Table 3-18, the eligible population for single family sector and commercial sector increased significantly based on the primary credit data. In addition, the implied discount rate reduction for the single family sector and the multi-family sector increased, implying higher savings estimated from financing in Stage 1. Navigant left other financing model assumptions intact; the 2013 Study report captures details on other modeling assumptions.

4. Results

4.1 Statewide Potential

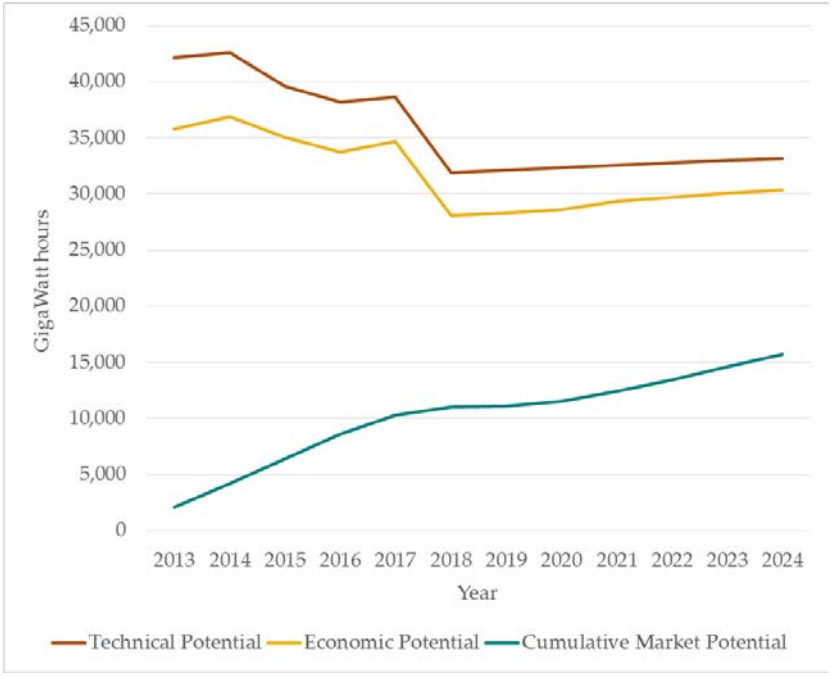
4.1.1 Technical, Economic and Cumulative Market Potential

Figure 4-1 through Figure 4-6 illustrate the statewide technical economic and cumulative market potential from IOU equipment rebates for electric (GWh), demand (MW) and gas (MMTherms) as well as savings as a percent of sales.[66] Theses graphs do not show IOU claimable savings from C&S advocacy programs or behavior programs nor do they include the effects of energy efficiency financing. The figures represent the remaining potential starting in 2013 (i.e. the effects of previous installations of high efficiency equipment prior to 2013 are accounted).

Figure 4-1 shows a technical potential of approximately 38,000 GWh in 2016 and an economic potential of approximately 33,700 GWh. Cumulative market potential grows at a relatively constant rate from 2013 to 2017 when its trajectory slows. This change in trajectory is due to the effects of new lighting C&S that come into effect in 2018 and decrease the IOU claimable savings. Technical and economic potential also decrease in 2018 due to changes in lighting C&S. Figure 4-2 shows statewide technical and economic electric potential as a percent of sales start at approximately 21% and 18% respectively in 2016 and drop to below 16% by 2024. Cumulative market potential grows to approximately 8% of sales by 2024. Figure 4-3 and Figure 4-4 show similar trends in demand potential.

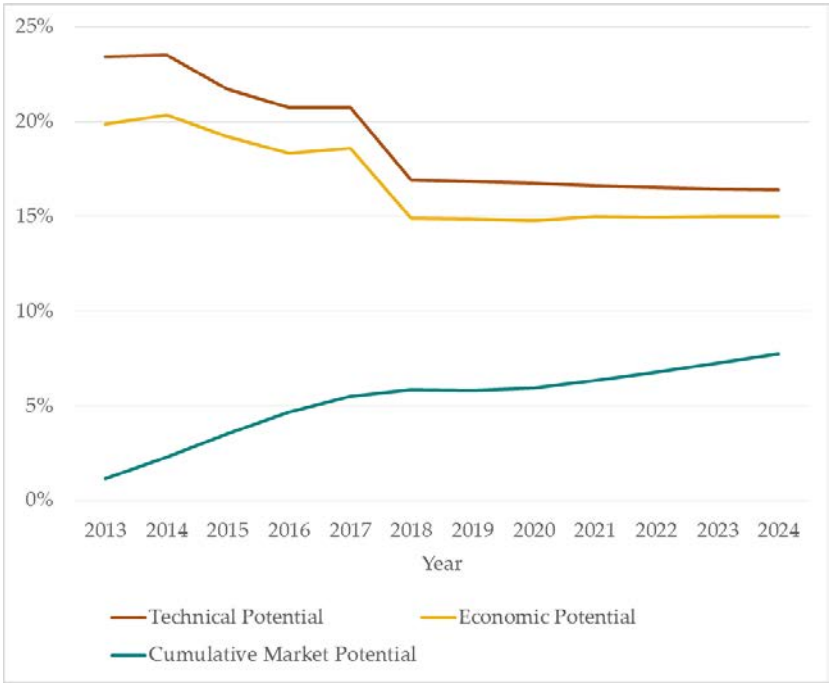
[66] Savings as a percent of sales reflects the value calculated when dividing energy efficiency potential in any given year by the forecasted energy consumption for that year. Forecasted energy consumption is sourced from the CEC.

Figure 4-1: Statewide Electric Technical, Economic and Cumulative Market Potential



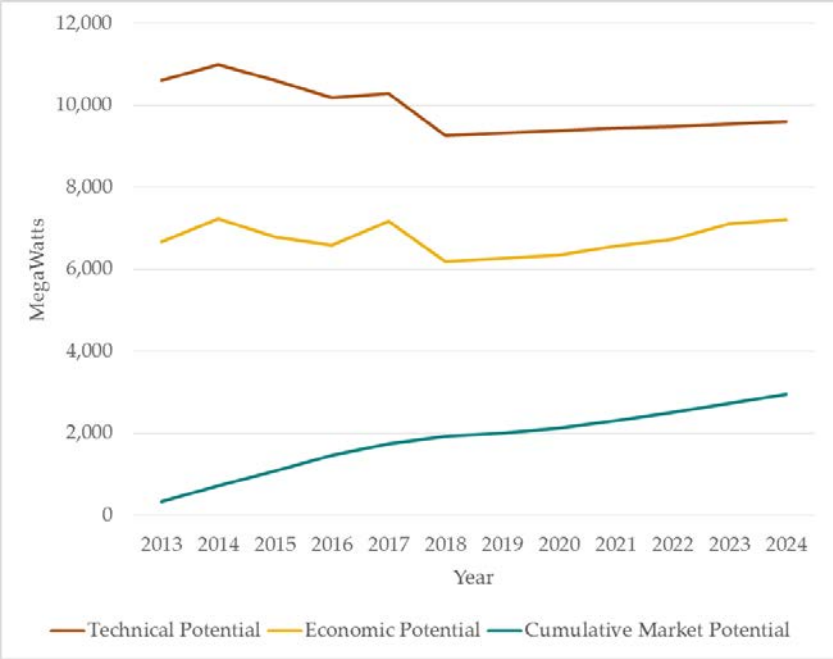
Source: June 2015 PG Model

Figure 4-2: Statewide Electric Potential as a Percent of Sales



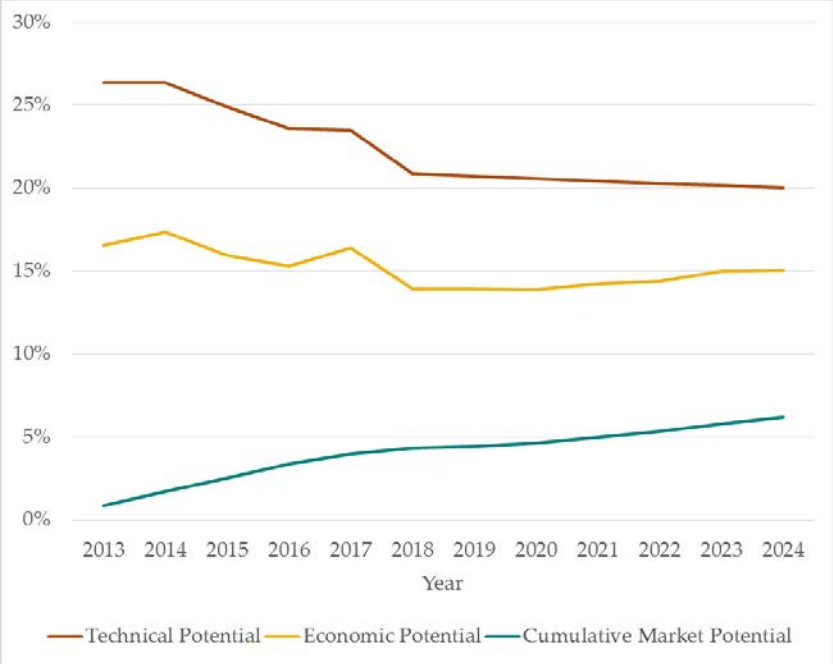
Source: June 2015 PG Model

Figure 4-3: Statewide Peak Demand Technical, Economic and Cumulative Market Potential



Source: June 2015 PG Model

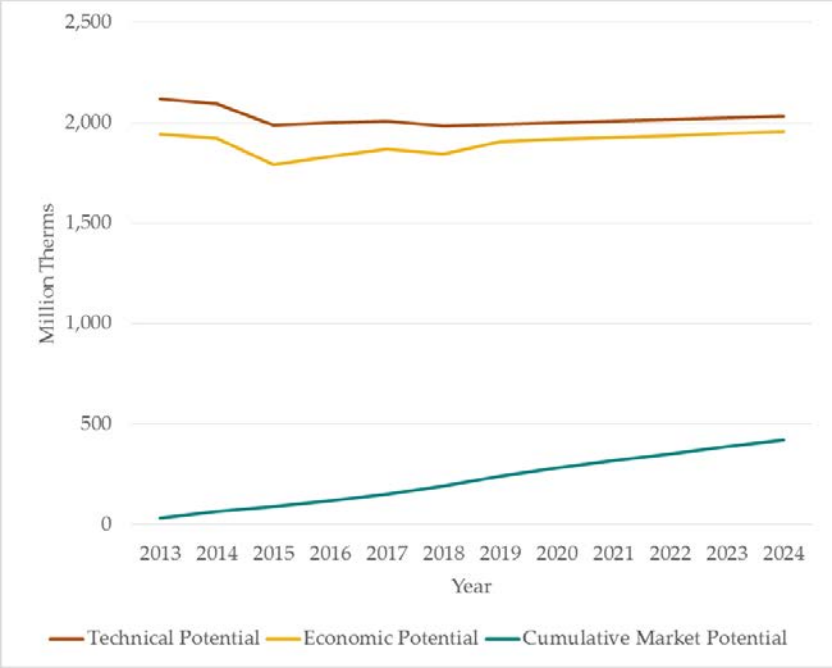
Figure 4-4: Statewide Peak Demand Potential as a Percent of Sales



Source: June 2015 PG Model

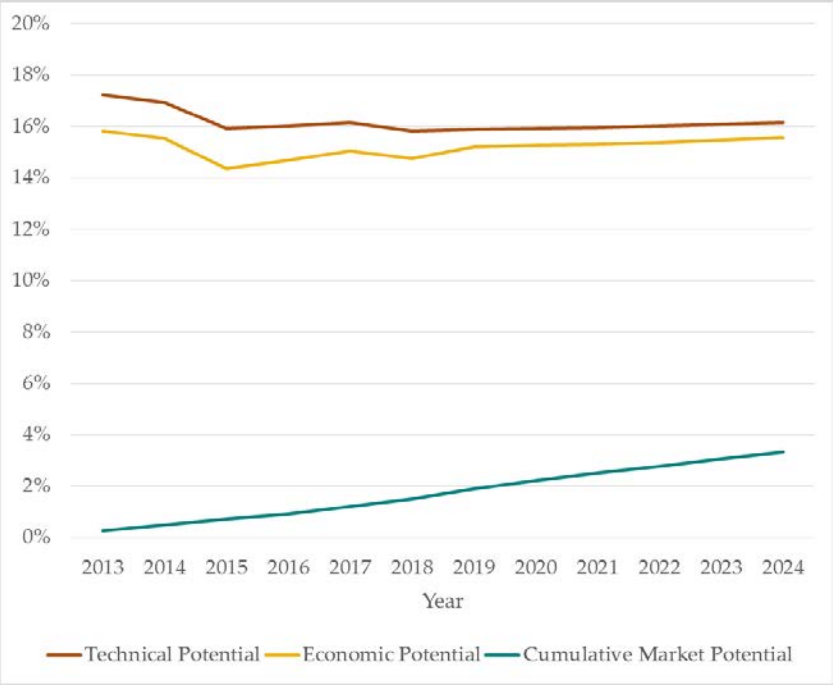
Figure 4-5 shows a technical potential of approximately 2,000 MMTherms in 2016 and an economic potential of approximately 1,800 MMTherms. Cumulative market potential grows at a relatively constant rate throughout the study period. Figure 4-6 shows statewide technical and economic gas potential as a percent of sales start at approximately 16% and 14.5% respectively in 2016 and stay relatively consistent through 2024. Cumulative market potential grows to approximately 3.3% of sales by 2024.

Figure 4-5: Statewide Natural Gas Technical, Economic and Cumulative Market Potential



Source: June 2015 PG Model

Figure 4-6: Statewide Natural Gas Potential as a Percent of Sales



Source: June 2015 PG Model

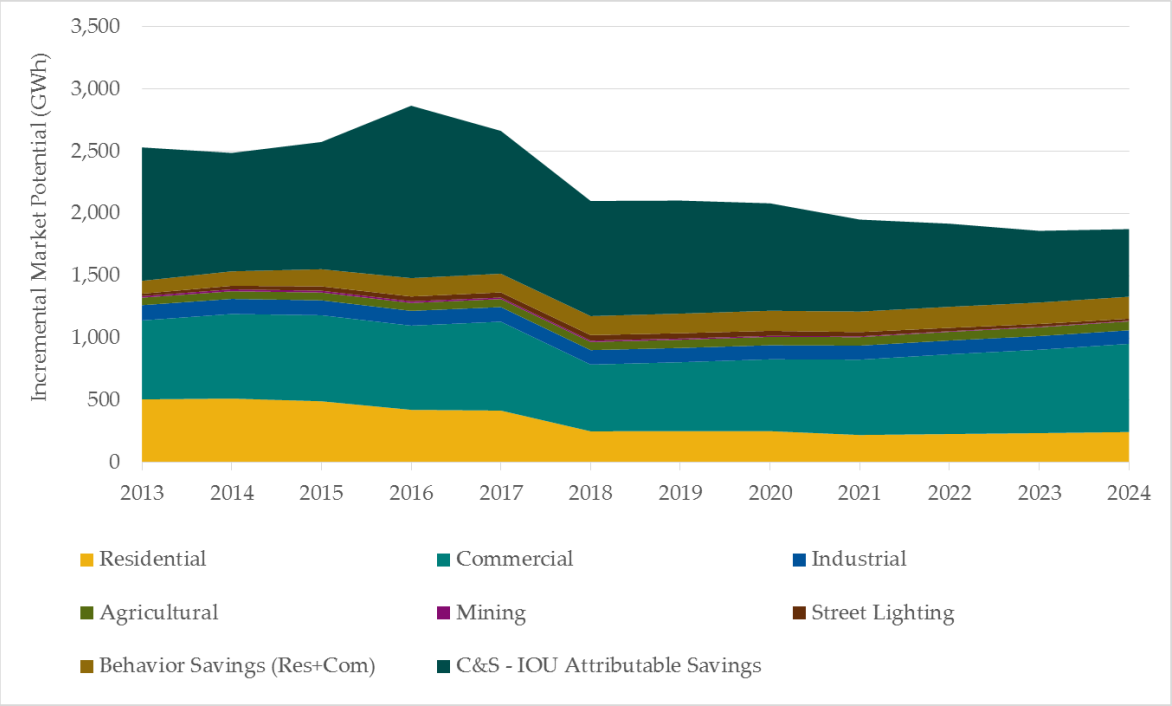
4.1.2 Incremental Market Potential

Figure 4-7 through Figure 4-9 illustrate the statewide incremental market potential from IOU programs for electric (GWh), demand (MW) and gas (MMTherms) respectively. Theses graphs include IOU claimable savings from C&S advocacy programs and behavior programs but they do not include the effects of energy efficiency financing.

Figure 4-7 shows a large portion of IOU potential comes from IOU attributable C&S savings. Residential and Commercial rebated equipment has historically contributed a significant amount of savings to IOU programs and will continue to do so through 2017. In 2018, changes in lighting C&S act to reduce IOU claimable savings. The AIMS sectors remain a small portion of future potential. IOU behavior programs provide more electric savings than the agriculture, mining and streetlighting sectors combined.

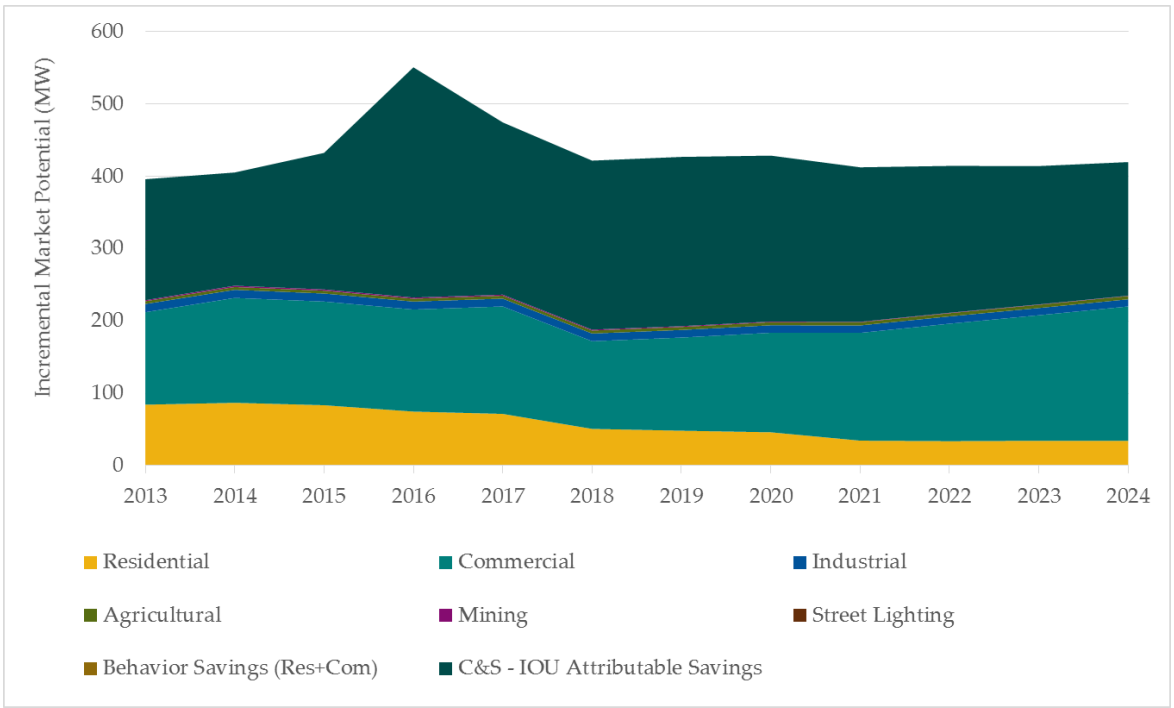
Figure 4-8 shows similar trends for peak demand savings with a few noted differences: behavior programs and street lighting measures do not have any quantified IOU claimable savings potential. Figure 4-8 also shows a spike in expected demand savings in 2016 from C&S. This spike is due to expected 2016 Title 20 HVAC standards regarding air filter labeling.

Figure 4-7: Statewide Incremental Electric Potential



Source: June 2015 PG Model

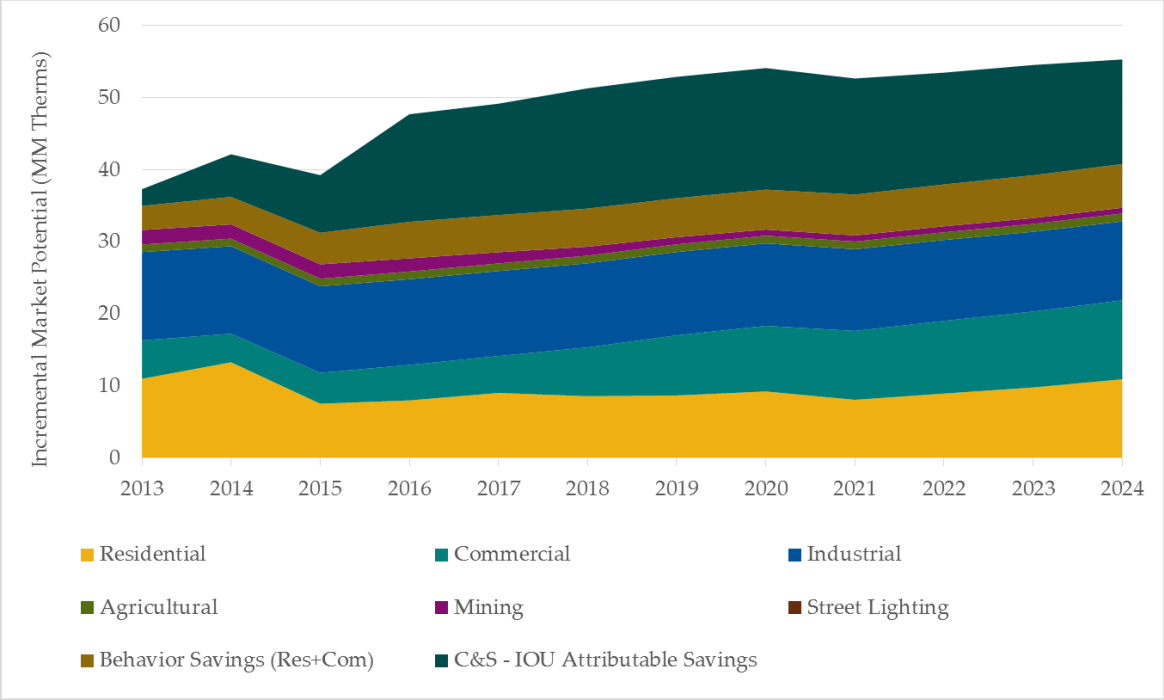
Figure 4-8: Statewide Incremental Demand Potential



Source: June 2015 PG Model

Figure 4-9 shows larger contributions by the Industrial and Mining sectors towards total gas savings potential. Residential and Commercial savings are expected to grow in 2016 and beyond. C&S savings will continue to play a role in IOU program potential but is not as significant of a contributor when compared to electric savings. Like electric potential, IOU behavior programs provide more gas savings than the agriculture, mining and streetlighting sectors combined.

Figure 4-9: Statewide Incremental Natural Gas Potential



Source: June 2015 PG Model

4.1.3 Incremental Market Potential as a Percent of Energy Sales

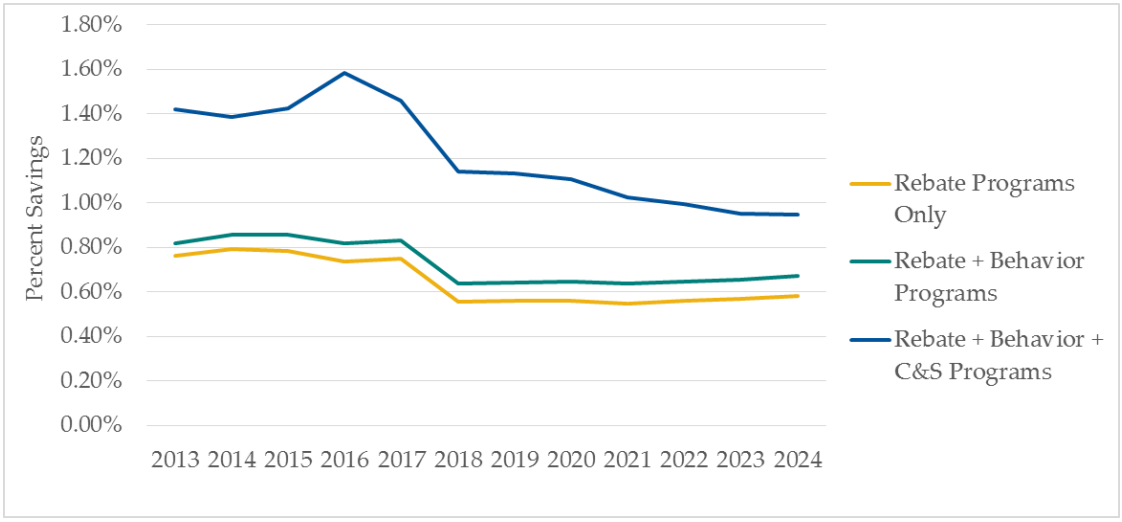
The proposed Assembly Bill 1330 would create an Energy Efficiency Resource Standard (EERS) in California; a statewide target for electric and natural gas efficiency savings. AB 1330, as currently written, would set the following targets:

- Incremental electric savings achieved of no less than 1.5% in 2020 and 2% in 2025
- Incremental natural gas savings achieved of no less than 0.75% in 2020 and 1% in 2025
- Percent savings shall be determined based upon the average retail sales of electricity and natural gas of the immediately preceding three years

Given these possible targets, the study calculated the percent savings by dividing incremental market potential by retail energy sales forecast from the CEC. Retail sales were converted to a three-year historic rolling average per the language of AB 1330.

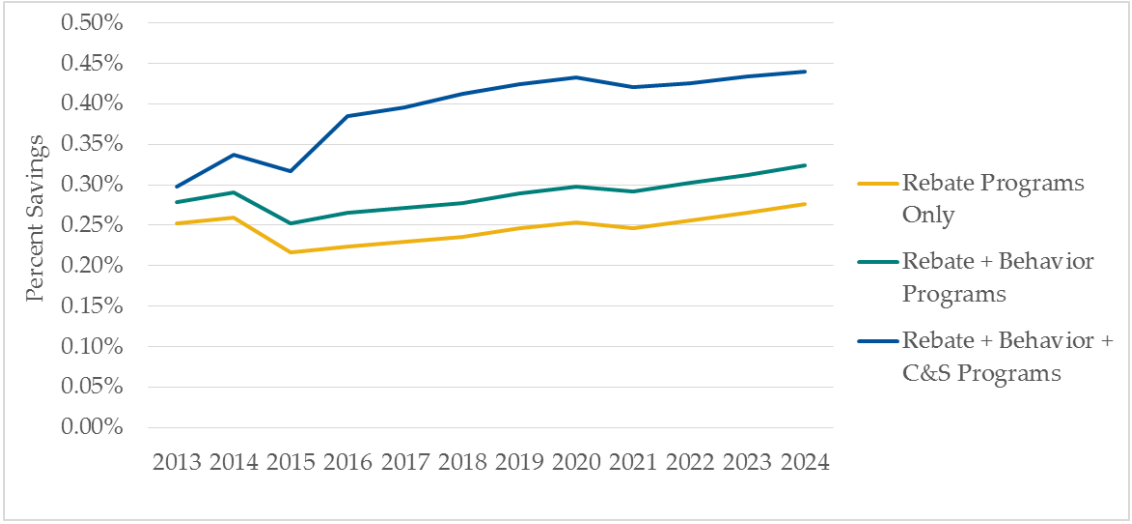
Figure 4-10 illustrates the percent savings in each year considering three sources of savings (rebate programs, behavior programs and IOU C&S programs). It is unclear at this time which sources of savings can and should be counted towards AB 1330 targets. When considering only IOU rebate programs, savings in 2016 amounts to 0.74% of sales. Adding the savings from behavior programs increases the value to 0.82%. The total savings from rebate programs, behavior programs and C&S in 2016 results in 1.58% savings. Savings as a percent of retail sales declines over time. A similar graph for gas savings can be found in Figure 4-11. In all analyzed situations, gas savings is less than 0.5% of CEC forecasted gas sales.

Figure 4-10: Statewide IOU Electric Savings as a Percent of Annual Sales



Source: June 2015 PG Results Viewer

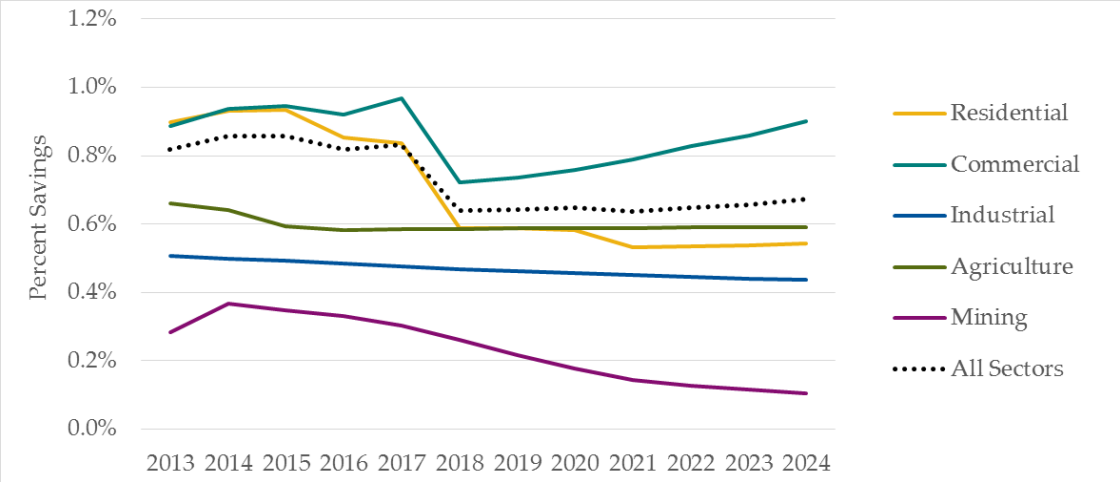
Figure 4-11: Statewide IOU Natural Gas Savings as a Percent of Annual Sales



Source: June 2015 PG Results Viewer

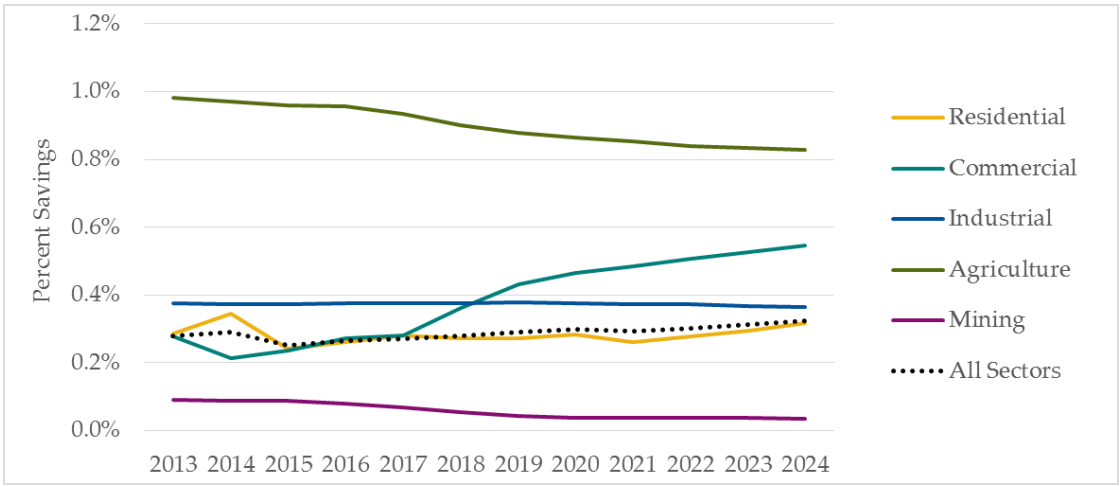
Figure 4-12 dives deeper into rebate program and behavior program savings for each sector. The graphs exclude savings from C&S. In 2016, Commercial program savings amount to 0.92% of Commercial electric sales, Residential programs result in 0.85% savings and while Industrial programs amount to 0.48% savings. The overall impact of all sectors is shown as the dotted line labeled "All Sectors". Figure 4-13 shows a similar graphic for gas savings.

Figure 4-12: Sector Level IOU Electric Program Savings as a Percent of Annual Sales



Note: Streetlighting not shown for scale. Streetlighting averages above 2% for the entire study period.
Source: June 2015 PG Results Viewer

Figure 4-13: Sector Level IOU Gas Program Savings as a Percent of Annual Sales



Source: June 2015 PG Results Viewer

4.2 Market Potential by IOU Territory

The following tables (Table 4-1 through Table 4-4) detail the annual incremental market potential for each IOU from 2016 through 2024. The potential is disaggregated by rebate programs (including behavior programs) as well as net C&S (IOU claimable) savings. Savings values for PG&E and SDG&E

include interactive effects (the impact of electric energy efficiency on gas savings) while savings for SCE and SCG exclude these interactive effects. IOU rebate program potential shown in the tables below are gross incremental annual savings while the IOU claimable C&S savings are net IOU attributable annual savings. Savings values for SDG&E further reflect an adjustment to whole building savings to be consistent with CPUC Decision 14-10-046 (further discussion can be found in section 1.4).

Table 4-1: PG&E Market Potential

	GWh			MW			MMTherms		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	624.5	611.3	1,235.9	85.0	140.6	225.6	12.9	5.5	18.4
2017	637.4	506.5	1,143.9	87.4	105.2	192.6	12.9	5.7	18.6
2018	507.4	408.3	915.7	68.9	103.2	172.1	14.8	6.1	20.9
2019	510.9	401.0	911.9	69.6	103.3	173.0	14.9	6.2	21.1
2020	519.1	380.9	900.0	71.4	101.3	172.7	15.5	6.2	21.7
2021	523.9	326.2	850.1	74.4	94.3	168.8	15.9	5.9	21.8
2022	541.2	294.7	835.9	80.3	89.7	170.0	16.7	5.7	22.4
2023	558.2	254.1	812.3	86.3	84.4	170.7	17.5	5.6	23.2
2024	581.3	239.8	821.1	91.7	81.5	173.3	18.6	5.3	23.9

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model

Table 4-2: SCE Market Potential

	GWh			MW			MMTherms		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	673.8	630.5	1,304.4	122.3	145.0	267.3	0.0	0.0	0.0
2017	693.5	522.4	1,215.9	123.0	108.5	231.4	0.0	0.0	0.0
2018	527.7	421.1	948.8	99.4	106.4	205.8	0.0	0.0	0.0
2019	541.8	413.6	955.3	103.1	106.6	209.7	0.0	0.0	0.0
2020	553.0	392.9	945.9	106.9	104.5	211.4	0.0	0.0	0.0
2021	542.4	336.5	878.9	103.3	97.3	200.6	0.0	0.0	0.0
2022	558.8	304.0	862.7	108.6	92.5	201.1	0.0	0.0	0.0
2023	573.2	262.1	835.4	113.2	87.1	200.3	0.0	0.0	0.0
2024	592.8	247.3	840.2	118.8	84.1	202.9	0.0	0.0	0.0

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model

Table 4-3: SCG Market Potential

	GWh			MW			MMTherms		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S**	Total
2016	0.0	0.0	0.0	0.0	0.0	0.0	17.3	11.7	29.1
2017	0.0	0.0	0.0	0.0	0.0	0.0	18.1	12.2	30.3
2018	0.0	0.0	0.0	0.0	0.0	0.0	16.6	12.7	29.4
2019	0.0	0.0	0.0	0.0	0.0	0.0	18.0	12.6	30.6
2020	0.0	0.0	0.0	0.0	0.0	0.0	18.4	12.2	30.6
2021	0.0	0.0	0.0	0.0	0.0	0.0	17.7	10.9	28.6
2022	0.0	0.0	0.0	0.0	0.0	0.0	18.2	10.3	28.5
2023	0.0	0.0	0.0	0.0	0.0	0.0	18.6	9.6	28.2
2024	0.0	0.0	0.0	0.0	0.0	0.0	19.0	9.1	28.1

**Includes behavior programs, excludes effects of financing.*
***Excludes interactive effects*
Source: June 2015 PG Model

Table 4-4: SDG&E Market Potential

	GWh			MW			MMTherms		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	181.0	143.1	324.1	24.5	32.9	57.4	2.6	0.6	3.2
2017	185.0	118.6	303.5	25.7	24.6	50.3	2.7	0.6	3.3
2018	140.8	95.6	236.4	19.6	24.1	43.7	3.2	0.7	3.9
2019	143.7	93.8	237.6	20.1	24.2	44.2	3.2	0.7	3.9
2020	147.3	89.2	236.4	20.9	23.7	44.6	3.3	0.7	4.0
2021	146.6	76.4	223.0	21.1	22.1	43.2	3.0	0.7	3.7
2022	151.3	69.0	220.3	22.5	21.0	43.4	3.1	0.6	3.7
2023	154.4	59.5	213.9	23.4	19.8	43.2	3.2	0.6	3.8
2024	158.1	56.1	214.2	24.5	19.1	43.6	3.2	0.6	3.8

**Includes behavior programs, excludes effects of financing, and includes adjustment to whole building savings to be consistent with CPUC Decision 14-10-046.*
Source: June 2015 PG Model

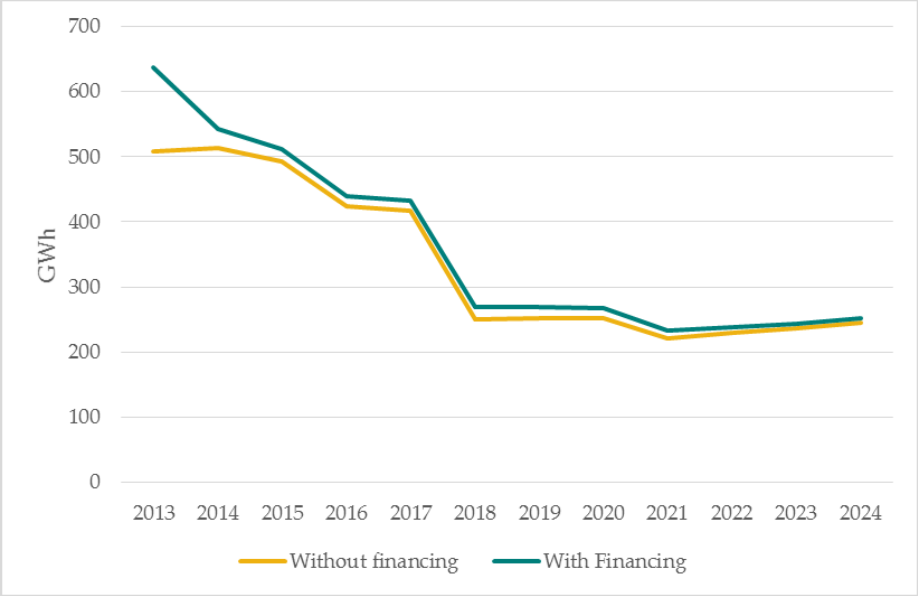
4.3 Effects of Financing on Potential

The introduction of financing reduces market barriers to energy efficiency technology adoption. To estimate the influence of financing, the PG model calculates savings potential by sector for two scenarios:

with financing and without financing. The difference between the two scenarios represents the incremental savings estimate due to energy efficiency financing.

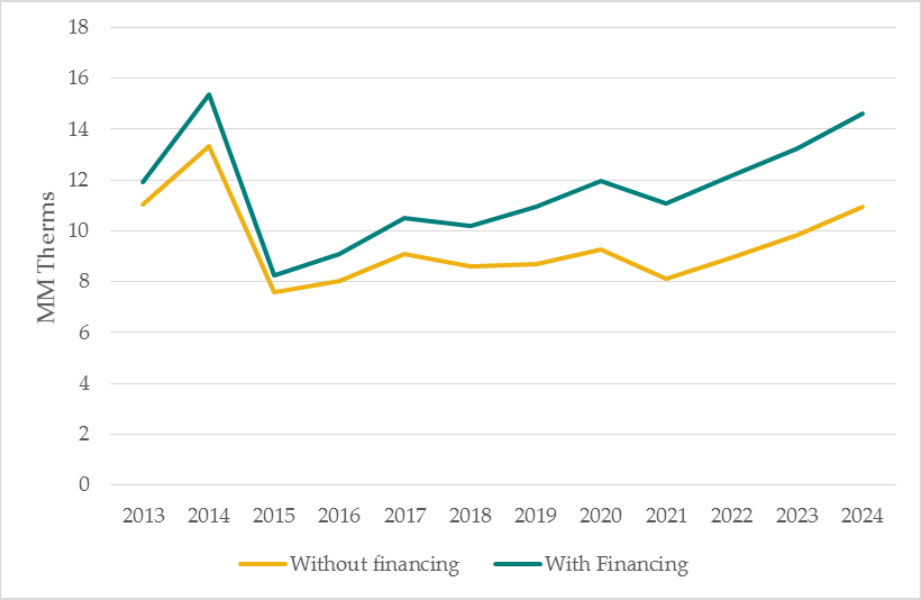
Financing increases residential sector incremental electric savings by an average of 4.5 percent (Figure 4-14) while increasing gas savings by 20.8 percent (Figure 4-15) over the 2016 -2024 time frame. The sum of all additional first year savings due to financing from 2016-2024 amounts to 117 GWh and 22 MMTherms in the residential sector. In 2016, financing adds 16.3 GWh and 1.05 MMTherms to the residential incremental savings. The impact due to financing in 2016 is equivalent to an additional 3.7% incremental first year electric savings and 11.6% incremental first year gas savings in the residential sector.

Figure 4-14: Residential Incremental Electric Savings Potential due to Financing (GWh)



Source: June 2015 PG Model

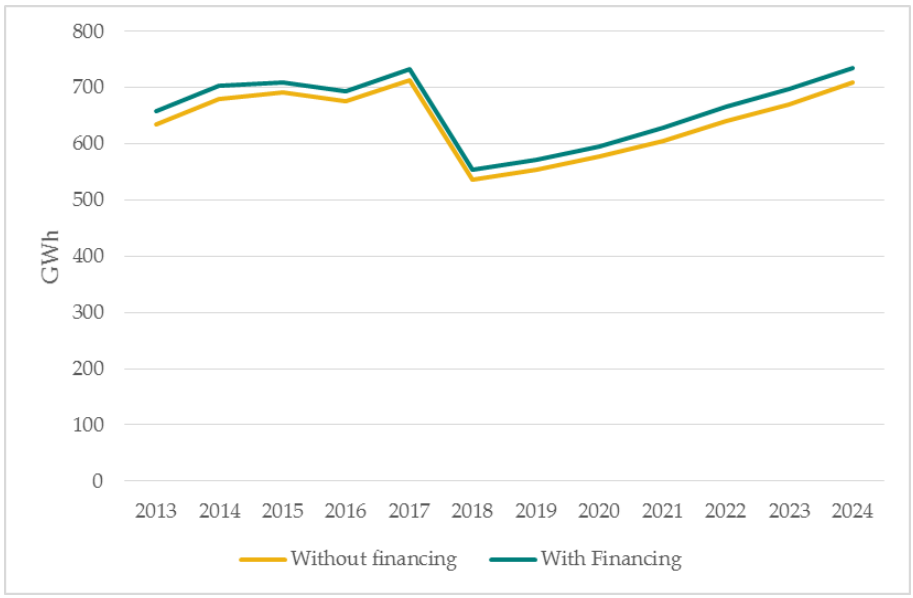
Figure 4-15: Residential Incremental Gas Savings due to Financing (MM Therms)



Source: June 2015 PG Model

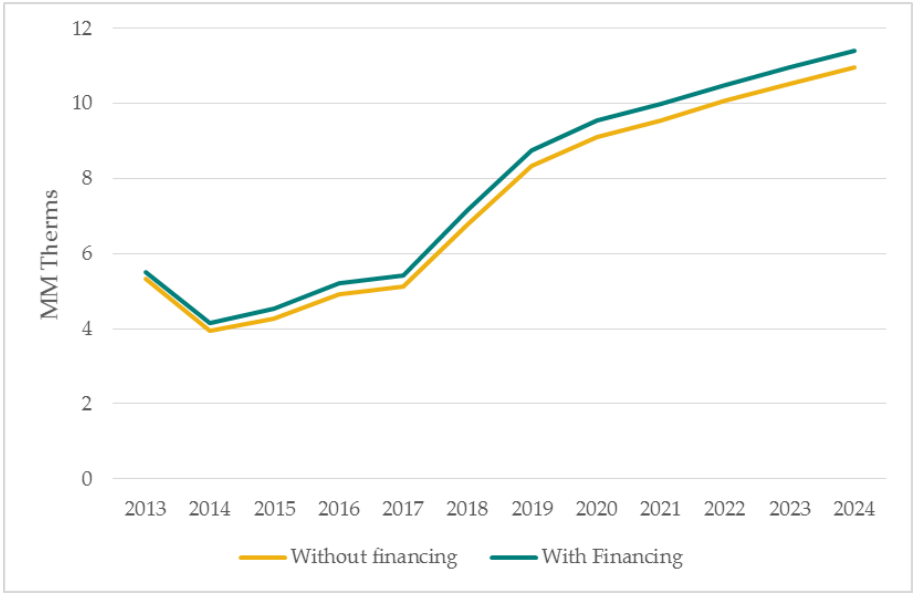
The impact of financing on the commercial sector increases electric savings by 3.3 percent (Figure 4-16) and gas savings by 4.7 percent (Figure 4-17) on average from 2016 to 2024. This translates to 193 GWh and 3.6 MM Therms of total first year electric and gas savings in the commercial sector from 2016-2024. In 2016 financing in the commercial sector can increase savings by 17.6 GWh (2.5 percent increase) and 0.3 MMTherms (5.6 percent increase).

Figure 4-16: Commercial Incremental Electric Savings due to Financing (GWh)



Source: June 2015 PG Model

Figure 4-17: Commercial Incremental Gas Savings due to Financing (MM Therms)



Source: June 2015 PG Model

Two key considerations are bounding the potential of financing in the commercial sector:

1. Population eligibility and
2. The reduction in implied discount rate assumptions.

Financing is slightly less available to commercial customers than residential customers. In the context of California energy efficiency financing landscape, the IOU energy efficiency financing pilot programs are designed to make financing accessible to the majority of residential customers. The minimum program requirement of a 580 FICO score potentially qualifies 98 percent of the residential customers. Compare to the residential sector, 77 percent of businesses have low or medium credit risk representing the eligible population for financing.

Based on Navigant's market research, residential sector customers have a much higher implied discount rate than commercial customers. Financing has a more significant reduction to residential customer implied discount rate than commercial customer implied discount rate.

4.4 Detailed Stage 1 Results

Along with the model file and the summary results shown above, the team developed a downloadable excel tool, the 2015 PG Results Viewer, which provides access to all detailed mid-case results from the model. The Results Viewer provides stakeholders the ability to manipulate and visualize model outputs from the high-level statewide standpoint all the way to the granular measure level. The Results Viewer is

structured with multiple tabs to view summary results as well as detailed model outputs, as seen in Table 4-5. The results viewer can be found on the CPUC's website.[67]

Table 4-5: 2015 PG Results Viewer Tabs

Summary Outputs	Detailed Output Viewing	
Data Key	CEC Sales Data	Incremental Codes and Standards
Technical, Economic and Market Potential	Incremental Market Potential	Cumulative Codes and Standards
IOU Potential	Technical Potential	Behavior
Use Category Dashboard	Economic Potential	Incremental Market Potential Financing
Percent Savings Dashboard	Cumulative Market Potential	Cumulative Market Potential Financing
C&S and Behavior Dashboard		
Financing Dashboard		

Following is a brief description of each of the Summary Outputs tabs:

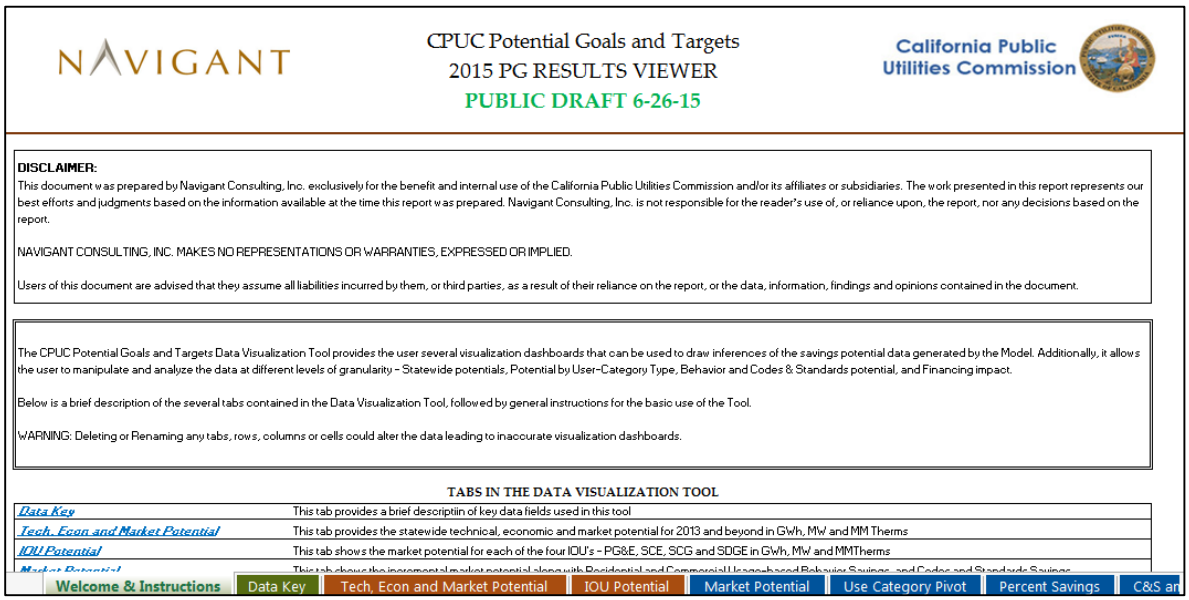
- Technical, Economic and Market Potential: This tab provides the statewide technical, economic and market potential for 2013 and beyond. The user can further filter and view results by IOU.
- IOU Potential: This tab shows the market potential for each of the four IOU's.
- Use Category Dashboard: This tab provides the user the ability to visualize the Incremental Market Potential results by End Use Categories. It also allows the user to manipulate the model outputs based on their needs through filters such as Service Territory, Building Type, Sector etc.
- Percent Savings Dashboard: This tab shows the incremental market potential as a percent of total energy sales.
- C&S and Behavior Dashboard: This tab shows the Codes and Standards, and Behavior potential for all four IOU's. It also allows the user to manipulate the model outputs based on their needs through filters such as Service Territory, Savings Type and Sector.
- Financing Dashboard: This tab shows the effects of financing on incremental market potential for Residential and Commercial sectors

On the other hand, the Detailed Output Viewing tabs contain all the raw model outputs, as well as the raw CEC Sales Data. The raw model outputs is the source data for all the dashboard visualizations provided, and additionally gives the user the ability to perform custom analysis based on their needs. Figure 4-18 through Figure 4-21 will show some snapshots of the tool.

[67] http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Energy+Efficiency+Goals+and+Potential+Studies.htm

Figure 4-18 is a snapshot of the Results Viewer Main Page that provides a high level summary of the tool, a brief description of each tab and some general instructions.

Figure 4-18: Results Viewer Main Page



As discussed previously, the Results Viewer provides various Summary Outputs tabs, one of which is highlighted in Figure 4-19. The layout of the results page has graphics on either side of the summary model outputs, to provide the user the ability to visually see the information, as well as seeing the model outputs that is represented in the graphs.

Figure 4-19: Tech, Econ and Market Potential Page

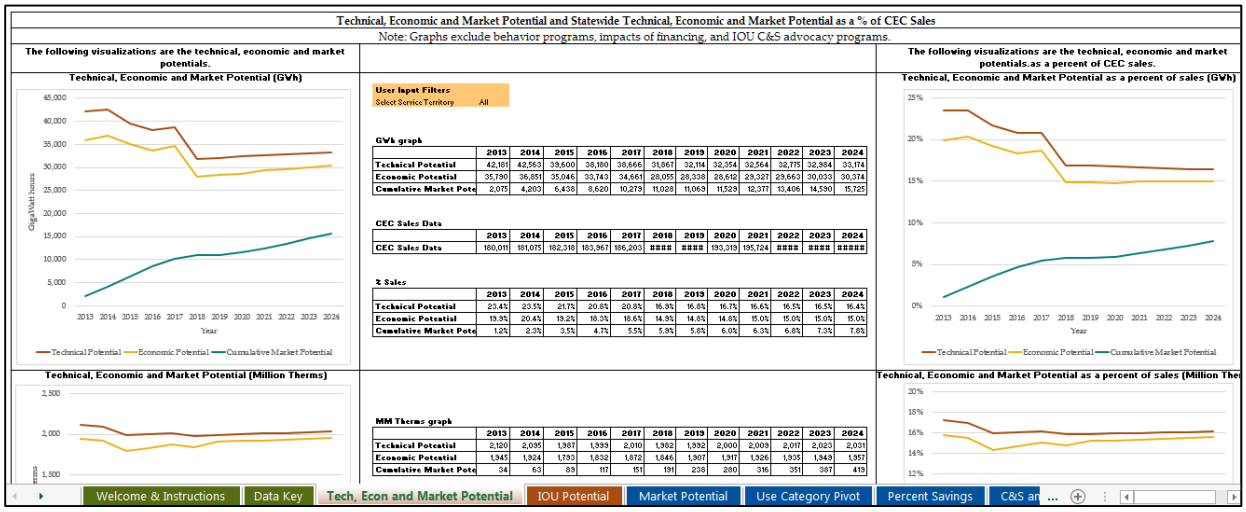
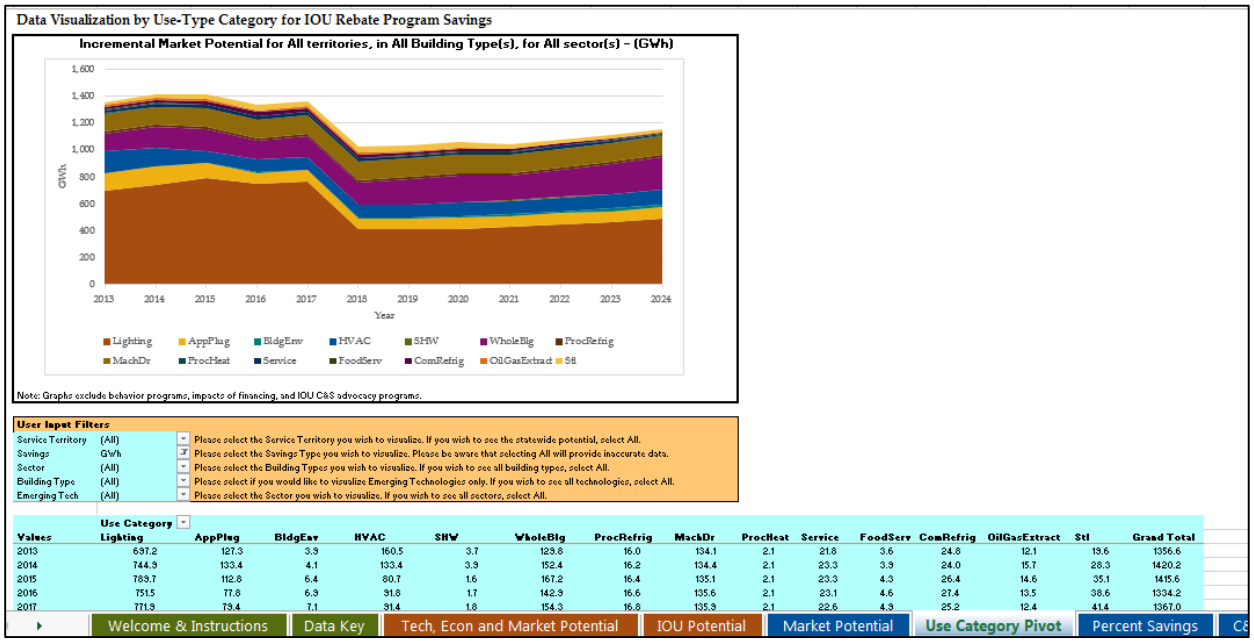


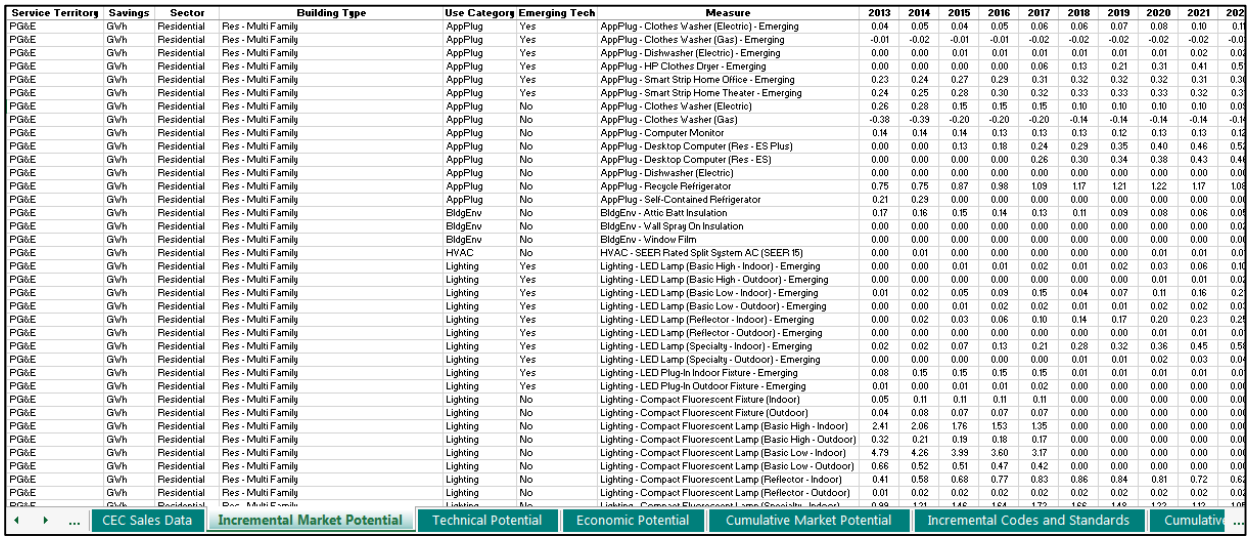
Figure 4-20 is a snapshot of the Use-Category Dashboard that gives the user over 300 different views of the results based on user defined selections of several key parameters (IOU, savings type, sector, building type, inclusion of ETs). The page layout is designed to be as simple as possible with the graphic at the top, the user-customizable filters below, followed by a table of the model outputs being plotted. The table (like the graph) is auto-updated based on the user selections.

Figure 4-20: Use-Category Dashboard Page



Lastly, Figure 4-21 provides a snapshot of the detailed output format that is provided in the Results Viewer. The figure illustrates the incremental market potential. This table contains energy savings data for each measure in each IOU, building type, use category, measure type (emerging vs. conventional), sector, and year. The data resides in a format that is database-friendly and can be exported to other programs for additional user analysis.

Figure 4-21: Incremental Market Potential Page



Service Territory	Savings	Sector	Building Type	Use Category	Emerging Tech	Measure	2013	2014	2015	2016	2017	2018	2019	2020	2021	202
PG&E	GWh	Residential	Res - Multi Family	AppPlug	Yes	AppPlug - Clothes Washer (Electric) - Emerging	0.04	0.05	0.04	0.05	0.06	0.06	0.07	0.08	0.10	0.1
PG&E	GWh	Residential	Res - Multi Family	AppPlug	Yes	AppPlug - Clothes Washer (Gas) - Emerging	-0.01	-0.02	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.0
PG&E	GWh	Residential	Res - Multi Family	AppPlug	Yes	AppPlug - Dishwasher (Electric) - Emerging	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.0
PG&E	GWh	Residential	Res - Multi Family	AppPlug	Yes	AppPlug - HP Clothes Dryer - Emerging	0.00	0.00	0.00	0.00	0.06	0.13	0.21	0.31	0.41	0.5
PG&E	GWh	Residential	Res - Multi Family	AppPlug	Yes	AppPlug - Smart Strip Home Office - Emerging	0.23	0.24	0.27	0.29	0.31	0.32	0.32	0.32	0.31	0.3
PG&E	GWh	Residential	Res - Multi Family	AppPlug	Yes	AppPlug - Smart Strip Home Theater - Emerging	0.24	0.25	0.28	0.30	0.32	0.33	0.33	0.33	0.32	0.3
PG&E	GWh	Residential	Res - Multi Family	AppPlug	No	AppPlug - Clothes Washer (Electric)	0.26	0.28	0.15	0.15	0.15	0.10	0.10	0.10	0.10	0.0
PG&E	GWh	Residential	Res - Multi Family	AppPlug	No	AppPlug - Clothes Washer (Gas)	-0.38	-0.39	-0.20	-0.20	-0.20	-0.14	-0.14	-0.14	-0.14	-0.1
PG&E	GWh	Residential	Res - Multi Family	AppPlug	No	AppPlug - Computer Monitor	0.14	0.14	0.14	0.13	0.13	0.13	0.12	0.13	0.13	0.1
PG&E	GWh	Residential	Res - Multi Family	AppPlug	No	AppPlug - Desktop Computer (Res - ES Plus)	0.00	0.00	0.13	0.18	0.24	0.29	0.35	0.40	0.46	0.5
PG&E	GWh	Residential	Res - Multi Family	AppPlug	No	AppPlug - Desktop Computer (Res - ES)	0.00	0.00	0.00	0.00	0.26	0.30	0.34	0.38	0.43	0.4
PG&E	GWh	Residential	Res - Multi Family	AppPlug	No	AppPlug - Dishwasher (Electric)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	AppPlug	No	AppPlug - Recycle Refrigerator	0.75	0.75	0.87	0.98	1.09	1.17	1.21	1.22	1.17	1.0
PG&E	GWh	Residential	Res - Multi Family	AppPlug	No	AppPlug - Self-Contained Refrigerator	0.21	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	BldgEnv	No	BldgEnv - Attic Batt Insulation	0.17	0.16	0.15	0.14	0.13	0.11	0.09	0.08	0.06	0.0
PG&E	GWh	Residential	Res - Multi Family	BldgEnv	No	BldgEnv - Wall Spray On Insulation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	BldgEnv	No	BldgEnv - Window Film	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	HVAC	No	HVAC - SEER Rated Split System AC (SEER 15)	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Lamp (Basic High - Indoor) - Emerging	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.03	0.06	0.1
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Lamp (Basic High - Outdoor) - Emerging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Lamp (Basic Low - Indoor) - Emerging	0.01	0.02	0.05	0.09	0.15	0.04	0.07	0.11	0.16	0.2
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Lamp (Basic Low - Outdoor) - Emerging	0.00	0.00	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Lamp (Reflector - Indoor) - Emerging	0.00	0.02	0.03	0.06	0.10	0.14	0.17	0.20	0.23	0.2
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Lamp (Reflector - Outdoor) - Emerging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Lamp (Specialty - Indoor) - Emerging	0.02	0.02	0.07	0.13	0.21	0.28	0.32	0.36	0.45	0.5
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Lamp (Specialty - Outdoor) - Emerging	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Plug-In Indoor Fixture - Emerging	0.08	0.15	0.15	0.15	0.15	0.01	0.01	0.01	0.01	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	Yes	Lighting - LED Plug-In Outdoor Fixture - Emerging	0.01	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	No	Lighting - Compact Fluorescent Fixture (Indoor)	0.05	0.11	0.11	0.11	0.11	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	No	Lighting - Compact Fluorescent Fixture (Outdoor)	0.04	0.08	0.07	0.07	0.07	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	No	Lighting - Compact Fluorescent Lamp (Basic High - Indoor)	2.41	2.06	1.76	1.53	1.35	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	No	Lighting - Compact Fluorescent Lamp (Basic High - Outdoor)	0.32	0.21	0.19	0.18	0.17	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	No	Lighting - Compact Fluorescent Lamp (Basic Low - Indoor)	4.79	4.26	3.99	3.60	3.17	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	No	Lighting - Compact Fluorescent Lamp (Basic Low - Outdoor)	0.66	0.52	0.51	0.47	0.42	0.00	0.00	0.00	0.00	0.0
PG&E	GWh	Residential	Res - Multi Family	Lighting	No	Lighting - Compact Fluorescent Lamp (Reflector - Indoor)	0.41	0.58	0.68	0.77	0.83	0.86	0.84	0.81	0.72	0.6
PG&E	GWh	Residential	Res - Multi Family	Lighting	No	Lighting - Compact Fluorescent Lamp (Reflector - Outdoor)	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.0

CEC Sales Data | Incremental Market Potential | Technical Potential | Economic Potential | Cumulative Market Potential | Incremental Codes and Standards | Cumulativ

A revised version of the Tool will be developed and submitted along with Stage 2 deliverables, based on stakeholder feedback and updated model outputs, including the low and high cases scenarios.

4.5 Comparison of 2015 Study to 2013 Study Results

Significant data updates have been made in Stage 1 that cause results to depart from those previously stated in the 2013 Study. A comparison of statewide (all IOUS combined) savings found in Table 4-6 through Table 4-7.

Relative to the 2013 study, overall potential from electric rebate programs decreased slightly between 2016 and 2018 while potential from C&S increased during the same period. Thus total electric potential from 2016 to 2018 increased. Rebate program electric potential after 2018 (after major changes in lighting standards take effect) decrease relative to the 2013 study.

Relative to the 2013 study, overall potential from gas rebate programs decreased on the order of 20% from 2016 through 2024. However, during this same period potential from C&S increased significantly relative to the 2013 study. The net effect of both changes is an overall minimal change to the total potential over the 2016-2024 period though a 9% increase is observed in 2016 and 2017.

The key drivers behind the differences in the results of the two studies are listed below.

» The 2015 study uses more up-to date historic market data for the purposes of model calibration. The 2015 study uses evaluated program results from 2010-12 that was not available in the 2013 study as well as better data about the saturation of equipment from saturation surveys (CLASS and CSS).

» Residential and commercial measures assumptions about unit energy savings were sourced from the DEER2015 Update and 10-12 EM&V studies. Some additional adjustments to CFLs,

refrigerator recycling, and commercial lighting based on DEER2016 and the Ex Ante Uncertain Measures update.

» The 2015 study used updated measure cost data to characterize residential and commercial measures. The 2013 study in some case relied upon cost data from as early as 2008. HVAC and appliance measures saw the largest changes in cost given this data refresh.

» The CEC proved updated building stock and energy consumption forecasts.

» The updated CPUC evaluation of IOU C&S programs (2010-12 EM&V study) shows more savings than previous evaluation results (2006-08 EM&V study)

» Additional data about IOU behavior programs has generally increased behavior program savings

» Better data on LEDs was obtained. LED assumptions are more conservative in both price and efficacy in the 2015 study relative to the 2013 study. This results in a lower LED potential in the 2015 compared to the 2013 study. In the 2013, much of the increase in potential after 2018 came from LEDs. The post-2018 LED potential is more conservative given data updates.

Table 4-6: 2015 Stage 1 vs. 2013 Study Results: Electric Potential (GWh)

	2013 Study			2015 Stage 1			Difference		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	1,637	937	2,574	1,482	1,385	2,867	-9%	48%	11%
2017	1,600	734	2,334	1,517	1,147	2,665	-5%	56%	14%
2018	1,227	664	1,891	1,177	925	2,102	-4%	39%	11%
2019	1,335	644	1,979	1,196	908	2,105	-10%	41%	6%
2020	1,463	613	2,076	1,219	863	2,082	-17%	41%	0%
2021	1,589	517	2,106	1,213	739	1,952	-24%	43%	-7%
2022	1,720	458	2,178	1,251	668	1,919	-27%	46%	-12%
2023	1,829	366	2,195	1,286	576	1,862	-30%	57%	-15%
2024	1,932	337	2,269	1,332	543	1,875	-31%	61%	-17%

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model, and 2013 Study

Table 4-7: 2015 Stage 1 vs. 2013 Study Results: Demand Potential (MW)

	2013 Study			2015 Stage 1			Difference		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	266	192	458	232	319	551	-13%	66%	20%
2017	268	127	395	236	238	475	-12%	88%	20%
2018	218	123	341	188	234	422	-14%	90%	24%
2019	238	122	360	193	234	427	-19%	92%	19%
2020	262	119	381	199	230	429	-24%	93%	13%
2021	285	109	394	199	214	413	-30%	96%	5%
2022	311	103	414	211	203	415	-32%	97%	0%
2023	335	94	429	223	191	414	-33%	103%	-3%
2024	358	90	448	235	185	420	-34%	105%	-6%

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model, and 2013 Study

Table 4-8: 2015 Stage 1 vs. 2013 Study Results: Natural Gas Potential (MMTherms)

	2013 Study			2015 Stage 1			Difference		
Year	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total	Rebate Programs*	Net C&S	Total
2016	39.2	7.3	46.5	32.8	17.9	50.6	-16%	145%	9%
2017	39.0	9.1	48.1	33.7	18.5	52.2	-13%	103%	9%
2018	43.5	10.5	54.0	34.6	19.6	54.2	-20%	87%	0%
2019	45.1	11.2	56.3	36.1	19.5	55.6	-20%	74%	-1%
2020	47.1	11.3	58.4	37.3	19.1	56.3	-21%	69%	-4%
2021	48.9	10.2	59.1	36.6	17.5	54.1	-25%	71%	-9%
2022	50.8	10.0	60.8	38.0	16.6	54.6	-25%	66%	-10%
2023	52.4	9.9	62.3	39.3	15.9	55.2	-25%	61%	-11%
2024	54.1	9.7	63.8	40.8	15.0	55.9	-25%	55%	-12%

**Includes behavior programs, excludes effects of financing.*
Source: June 2015 PG Model, and 2013 Study

NAVIGANT

Appendix A. Calibration

A.1 Overview

Forecasting is the inherently uncertain process of estimating future outcomes by applying a model to historic and current observations. As with all forecasts, the PG model results cannot be empirically validated a priori, as there is no future basis against which one can compare simulated versus actual results. Despite that all future estimates are untestable at the time they are made, forecasts can still warrant confidence when historic observations can be shown to reliably correspond with generally accepted theory and models.

Calibration provides both the forecaster and stakeholders with a degree of confidence that simulated results are reasonable and reliable. Calibration is intended to achieve three main purposes:

- Ground the model in actual market conditions and ensure the model reproduces historic program achievements;
- Ensure a realistic starting point from which future projects are made; and
- Account for varying levels of market barriers across different types of technologies and end uses.

The PG model is calibrated by reviewing portfolio data from 2006 up through 2012 to assess how the market has reacted to program offerings in the past. The Navigant team used ex-post EM&V data from 2006-2012 as the calibration data and also compared results to the 2013-2014 compliance filing data.

The calibration data are used to inform the appropriate values for the customer willingness and awareness parameters that drive measure adoption during the model time horizon. These parameters are then considered to account for the range of factors—technological, economic, market, and program factors— that contribute to historic program achievements. This includes consumers' awareness of programs and their willingness to participate in them.

This calibration method (a) tracks what measures have been installed or planned for installation over an historic six-year period and (b) forecasts how remaining stocks of equipment will be upgraded, including the influence of various factors such as new codes and standards, emerging technologies, or new delivery mechanisms. The calibration approach is not applied to emerging technologies, as there is insufficient historical basis to adjust future adoption for these technologies.

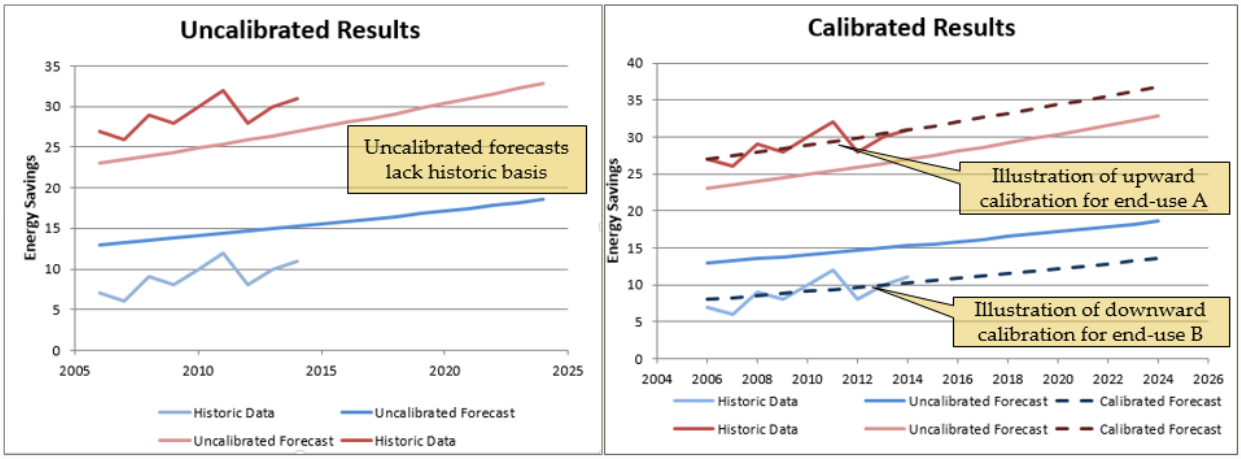
A.2 Necessity of Calibration

Calibration refers to the standard process of adjusting model parameters such that model results align with observed data. In evaluative statistical models, calibration is called *regression*, and goodness of fit is typically the main focus since the models are usually simple. In situations of complex dynamics and non-linearity (as in this study), model sophistication and adequacy can become the main focus. But grounding the model in observation remains equally necessary. The ability of a forecast to reasonably simulate observed data affords credibility and confidence to forecast estimates.

Although there are data supporting all underlying parameters in the PG model, much of the data are at an aggregate level that can be inadequate to forecast differences across the various classes of technologies and end uses. The customer willingness-to-adopt factor is a good example of this effect. Customers may exhibit certain average purchase tendencies in adopting measures based on their financial characteristics. However there may be features of certain end use technologies that cause customer behavior to vary from the average. Residential building envelope is an end use where adoption of measures like insulation is consistently lower than would be predicted compared with other end uses. Residential lighting adoption, on the other hand, performs better than the average predicted customer purchase tendencies, even after adjusting for differences in financial attractiveness. We often think of these differences as the influence of non-financial product attributes or of market barriers.

Figure A-1 below illustrates the concept of calibration. The chart on the left shows how certain end uses may over predict (blue) or under predict (red) adoption compared to observations of program participation. By adjusting the customer willingness factors, as illustrated in the right chart below, the modeled results in past years become aligned with reported historical program achievements.

Figure A-1: The Concept of Calibrating



Note that model parameters and results may be increased *or* decreased depending on the end use. We do not "calibrate down" on aggregate, but rather just "calibrate" the end uses both up and down as appropriate based on the data, as shown in the chart on the right above.

Calibration is not an optional exercise in modeling. One might suggest that the average customer data should be sufficient to make a reliable aggregated forecast. However there are two important non-linearities that compel us toward a more granular parameterization:

» Program portfolios are not evenly composed across end-uses. This leads to an uneven weighting issue whereby average customer willingness may not lead to the correct calculation of total savings.

» The dynamics in the model regarding the timing of adoption can become incompatible with the remaining potential indicated by program achievements. For example, if the forecast results were not calibrated for CFL lighting in the residential sector, the saturation may remain inaccurately low in early years and indicate a larger remaining potential in future years. Thus calibrating a willingness parameter upward may increase its potential in the early years but decrease its potential in later years. This implies that in the absence of IOU program intervention, residential CFLs would have historically had much lower adoption. Calibration therefore allows us to capture these program influences to more accurately reflect remaining potential.

This discussion is intended to highlight the necessity of calibration and the effective irrelevance of uncalibrated parameters. It may be tempting to "relax" the calibrated parameters back toward the average to measure the effect of what could be possible. But the uncalibrated results can be difficult to interpret and almost certainly would not produce feasible results for certain end uses. Thus they provide no basis for a reasonable forecast. Instead, we treat the calibrated results as the most basic set of interpretable results from which alternate scenarios are developed. Changes to calibrated parameters are not returned to the uncalibrated averages, but are rather explicitly developed based on the feasibility of values that parameters might take over time and how quickly the change might occur. This is discussed more in the last section of this brief.

A.3 Interpreting Calibration

Calibration can constrain market potential for certain end uses when aligning model results with past IOU energy efficiency portfolio accomplishments. Although calibration provides a reasonable historic basis for estimating future market potential, past program achievements may not capture the potential due to structural changes in future programs or changes in consumer values. Calibration can be viewed as holding constant certain factors that might otherwise change future program potential, such as:

» Consumer values and attitudes toward energy efficient measures;
» Market barriers associated with different end uses;
» Program efficacy in delivering measures; and
» Program spending constraints and priorities.

Changing values and shifting program characteristics would likely cause deviations from market potential estimates calibrated to past program achievements.

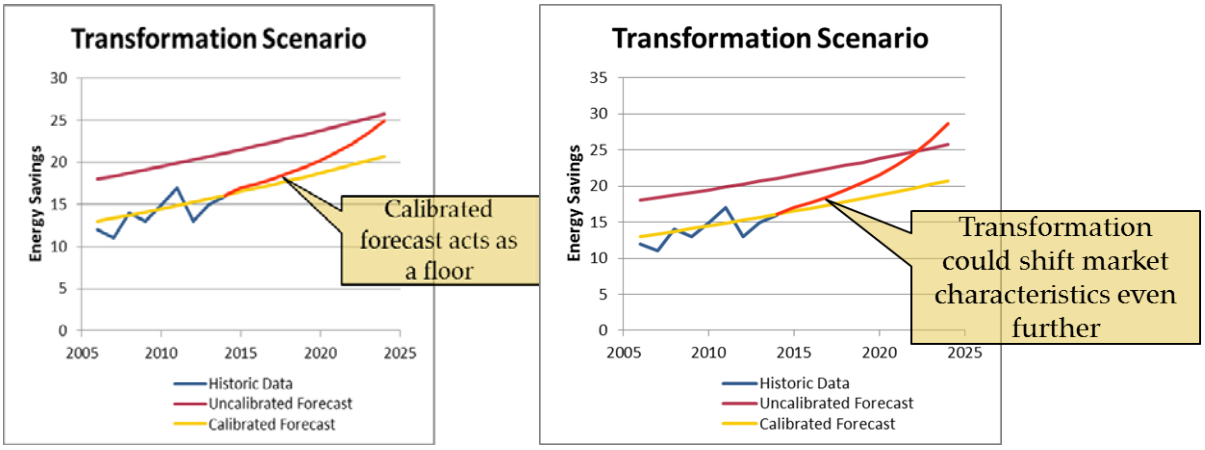
Does calibrating to historic data constrain the future forecast? In a strictly numeric sense, yes. If a certain end use is calibrated downward or upward, then future adoption and its timing are affected. However this should not be interpreted as "calibration constrains the level of adoption that we think is possible." Rather calibration provides a more accurate estimate of the current state of customer willingness, market barriers, program characteristics and remaining adoption potential. One forecast scenario might assume that the underlying conditions remain the same—a sort of business as usual scenario. We might develop another scenario such that it represents a transforming market based on agreed-upon end state parameter values appropriate for the end use market. For insulation that may mean a slight

improvement, for water heating a greater improvement, and for lighting perhaps little change is warranted if fewer market barriers exist today.

One interpretation is that the calibration process creates a floor for the remaining potential. Market barriers, customer attitudes, and program efficacy generally move in the direction of improvement. The extent to which a market or program can improve should not be compared to the uncalibrated results, but rather to the vision for what is reasonably possible for the paramters describing each end use. This may require little change, some change, or greater change in parameter values for different end-uses. But improvements to parameter values are based on their own merits and feasibility, and are independent of the uncalibrated paramter values and results.

Figure A-2 below shows two illustrative end uses where there is a calibrated base scenario (yellow) and alternative high scenarios (red) that are independent of the uncalibrated numbers (dark red). The chart on the left below shows a high forecast that may increase but still not meet the uncalibrated forecast, while the chart on the right shows a high forecast that exceeds the adoption of the uncalibrated forecast. The relation to the uncalibrated forecast is effectively arbitrary.

Figure A-2: Illustrative Transformative Scenarios



A.4 Implementing Calibration

Calibration examines three types of parameters to best align results with past program achievements:

- *Willingness parameters*
  - Primary target of calibration,
  - *Implied Discount Rate* – the iDR is adjusted when perceived market barriers are higher or lower than typical measures, or when factors other than financial characteristics may play a larger role in purchase decisions,
  - *Sensitivity* – the consumer sensitivity to the differences in financial attractiveness is adjusted when markets are considered mature and customer primary focus is measure financial attractiveness.

- » *Awareness parameters*
  - o Sometimes used, but only after willingness,
  - o Results are generally insensitive to awareness factors when measures are replace on burnout (ROB) with a measure life greater than 5 years because stock turnover dominates the timing,
  - o *Word of mouth and marketing factors* - For retrofit and short-lived measures awareness can be adjusted to better fit the timing of market growth.
- » *Initial awareness*
  - o Less influential, but frequently used to align the curvature of the adoption with 2013 market saturation data.
  - o Used to align the curvature of adoption timing with the estimated willingness and starting saturations.

Parameters are adjusted to fit historic observations during the calibration period. Then the parameters are applied to the forecast period, which begins in the year of most recent density data vintage. Calibrating parameters up and down can have different effects in a dynamic model depending on the initial saturation (i.e., density) data. For example, calibrating up can increase both historic and future adoption if the initial saturation is low. If initial saturation is high, then calibrating up can increase past adoption in the model, leaving less for future years.

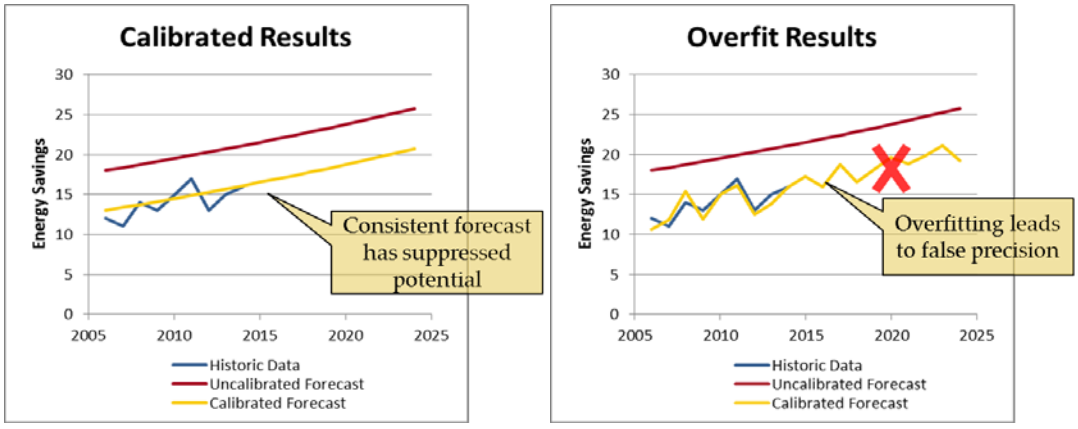
Once the consumer preference parameters are calibrated, the model forecast begins in 2013 by applying known market saturation data of that same vintage. Forecasts indicate the saturation of measures over time under the expected IOU future program influences.

A.5 Granularity of Calibration

The calibration process is undertaken at the sector and end use level for program activity in years 2006 to 2012.[68] The calibration accordingly accounts for the *cumulative* effect of market and program activity during these years. In our experience, this level is sufficient to capture the major differences in customer attitudes at the sector and end use level and to produce stable, reliable results over the forecast period. Overfitting the data (as illustrated in Figure A-3) can produce erratic model behavior that is beyond the precision of the forecast and the data that we use.

[68] Evaluation ex-post gross data were used for 2006-2012 from the CA Standard Program Tracking Database

Figure A-3: Proper and Improper Calibration



The data used for calibration are the ex post, gross evaluated program data. These data have units of energy savings such as MWh and Therms saved. By adjusting consumer preference parameters we can align the adoption and savings forecast over the calibration period with the actual evaluation data. This alignment is used by adjusting the consumer parameters for each sector, utility, and end use. The model is not calibrated at the building type or measure level for three reasons:

- The gain in precision of the results from calibrating at a lower level is expected to be negligible owing to the precision of the data sources for non-calibrated model inputs (e.g., density, building stocks, and calibration data).
- Calibrating at the lowest level of the model may give an appearance of rigor. But it is unlikely that customer preferences are represented by such sophisticated and highly dimensional reasoning. In other words, a highly granular model of consumer preferences would be at odds with the relative simplicity of the reasoning that consumers apply when making a purchase decision.
- Optimizing the non-linear model at the measure and building type level is a computationally intractable task that would require division into many batches—an enormously work- and time-intensive task due to the complexity of the model. It is not clear that such a path would lead to more accurate results and indeed might take away valuable resources from completing other aspects of the study scope.

The end use/sector/multiyear level of calibration was chosen because:

- The model variance is mostly explained at the sector and end use level making this level adequate to account for the most influential non-linear effects,
- The precision of lower level calibration results is not significantly improved beyond the chosen level,
- It is unlikely that in deciding to adopt a measure, consumers show very different purchase behavior toward similar technologies,
- Individual year calibration data are too noisy and inconsistent to fit and may lead to unreliable predictions.
- The chosen level of calibration strikes the right balance of analytical benefit versus cost.

Calibration of the PG model is performed at the back end of the modeling process in that input willingness and awareness parameters are iteratively (and manually) adjusted in the back end of the model until alignment is reached with ex post, gross evaluated data program data over the calibration period. The manual nature of this iterative task results in a lengthy process that requires repeatedly running the model, one sector and IOU at a time, to calibrate at the end-use level.

A.6 Scenario Analyses

This section offers an auxiliary discussion about scenario analyses not directly related to the process of calibration but brought up by stakeholders in relation to discussions about calibration.

Explicit Scenarios

Calibrated parameters provide the starting point for interpretable quantitative results. Scenarios are developed as explicit modifications to key variables the calibrated forecast such that the results can be easily interpreted. Multiple key variables can be changed in the calibrated forecast to produce results under different scenarios. These key variables fall under two categories:

1. Exogenous variables (events and outcomes that cannot be influenced) and
2. Endogenous variables (events and outcomes that can be influenced)

Disentanglement of Parameter Uncertainty from Policy and Program Levers in Scenarios

One factor that has obfuscated the interpretation of scenarios in the 2013 study is the combination of exogenous parameter uncertainty (e.g., retail rates, building stocks, technology curves, etc.) with the endogenous variables that may be influenced by policy and program implementation (e.g., measure inclusion criteria, codes and standards, variable incentive levels, or market transformation activities). This conflation of exogenous and controllable parameters within the scenarios made them difficult to interpret. Separation of exogenous parameter uncertainty from parameters that may be influenced or controlled will help disambiguate the meaning of the scenarios.

Navigant believes it is important to consider the effects of exogenous parameter estimates as a statement about the range of uncertainty stemming from several important factors that are beyond stakeholder's control--an effective uncertainty band. Then other parameters that represent the influence of policy and program decisions might be used to estimate credible increases in adoption, beyond the base calibrated results that might be achieved.

Maximum Achievable Potential

In previous discussions, some stakeholders have expressed a desire to use estimates of economic potential to convey the upper bound of what is possible. Although economic potential has a financial basis, it does not have a market basis. In particular, economic potential has no consideration of customer preferences nor does it account for the turnover of stock and the time scale of diffusion for different classes of technologies. For instance, future potential for ROB and long-lived measures generally are constrained by stock turnover rates which is not captured within economic potential. This leaves a

disconnect and a gap between economic potential and the upper bound of what could maximally be achieved with market-based program activities under idealized market conditions. Furthermore, the *maximum achievable potential (MAP)* is not a result that would likely be achieved under current conditions, but rather provides a maximum benchmark against which future market and program potential can be interpreted. The idea of MAP is one that would not penalize future potential based on current conditions, but rather show that programs will include strategies that might remove barriers over time which could lead to higher market adoption rates. In essence, such a scenario would illustrate future shifts in programmatic priorities and consumer attitudes that would increase future savings. Navigant will develop details for the MAP scenario as part of Stage 2 work.

A.7 Detailed Electric Calibration Inputs

Table A-1: PG&E Electric Detailed Calibration Inputs by Sector, End-Use, and Year (GWh)

Sector End-Use	2006	2007	2008	2009	2010	2011	2012	2006-2012 Total
Residential	206.86	504.21	722.23	434.65	683.82	527.95	454.80	3,534.52
AppPlug	36.98	72.15	82.92	48.71	98.58	83.59	57.38	480.32
BldgEnv	0.46	1.02	1.26	1.10	3.66	3.21	2.95	13.66
HVAC	2.43	3.95	4.35	3.50	7.69	3.95	4.45	30.31
Lighting	166.80	426.30	630.77	379.50	571.94	435.16	387.09	2,997.57
NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SHW	0.15	0.43	0.22	0.09	0.23	0.39	0.07	1.59
WholeBlg	0.04	0.35	2.71	1.75	1.73	1.65	2.85	11.08
Commercial	154.43	438.66	852.94	580.03	391.68	367.34	389.16	3,174.24
AppPlug	1.38	5.75	32.57	24.11	21.04	23.78	18.26	126.89
BldgEnv	2.49	4.61	6.05	2.20	1.70	1.58	1.38	20.00
ComRefrig	20.16	62.67	99.40	69.57	64.27	64.32	53.43	433.82
FoodServ	0.28	6.84	3.96	3.59	3.42	1.79	0.88	20.76
HVAC	17.20	57.54	138.37	105.52	86.83	80.46	79.22	565.15
Lighting	110.71	289.30	524.43	360.55	171.56	182.40	224.61	1,863.56
NA	1.54	11.91	47.43	12.80	5.49	3.45	2.01	84.63
ProcHeat	0.00	0.00	0.15	0.04	0.11	1.01	2.75	4.06
ProcRefrig	0.00	0.00	0.00	0.00	21.34	8.50	6.32	36.16
Service	0.00	0.00	0.00	1.63	15.81	0.00	0.00	17.44
SHW	0.68	0.04	0.58	0.03	0.11	0.04	0.29	1.77
Res/Com Total	361.29	942.87	1,575.17	1,014.67	1075.49	895.29	843.96	6,708.76

Source: Navigant analysis of CPUC Standard Program Tracking Database. 2014 (includes HVAC Interactive Effects)

Table A-2: SCE Electric Detailed Calibration Inputs by Sector, End-Use, and Year (GWh)

Sector End-Use	2006	2007	2008	2009	2010	2011	2012	2006-2012 Total
Residential	271.56	529.85	549.91	465.04	843.33	727.05	742.00	4,128.74
AppPlug	81.91	80.36	110.37	85.69	96.87	73.01	39.20	567.41
BldgEnv	0.01	0.21	0.41	2.04	1.40	0.78	0.06	4.91
HVAC	2.19	6.02	6.86	4.34	3.79	2.35	4.31	29.86
Lighting	184.23	434.59	386.58	366.20	722.98	641.98	668.97	3,405.53
Service	3.19	8.46	44.43	6.62	17.67	7.84	28.73	116.94
SHW	0.03	0.20	0.34	0.14	0.61	0.82	0.17	2.32
WholeBlg	0.00	0.00	0.93	0.00	0.00	0.29	0.56	1.77
Commercial	189.77	439.21	523.16	441.39	424.67	424.77	382.07	2,825.04
AppPlug	0.97	1.83	13.49	16.21	17.87	10.33	14.05	74.74
BldgEnv	1.18	1.72	2.25	0.84	4.37	7.71	3.04	21.11
CompAir	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.30
ComRefrig	14.49	16.57	30.34	18.77	39.45	58.97	36.55	215.13
FoodServ	0.15	10.64	1.42	3.98	2.23	1.90	1.66	21.98
HVAC	17.37	49.12	107.46	63.25	57.18	62.14	68.35	424.87
Lighting	135.48	309.60	337.20	292.93	268.28	263.22	231.44	1,838.14
NA	0.01	2.56	5.59	10.66	17.70	8.18	8.16	52.86
ProcHeat	0.00	0.21	0.23	0.00	0.00	0.00	0.15	0.59
ProcRefrig	0.00	0.00	0.00	0.00	0.60	1.12	3.51	5.23
Service	0.17	8.39	17.05	2.08	1.83	1.06	5.19	35.79
SHW	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.14
WholeBlg	19.86	38.54	8.14	32.66	15.15	10.15	9.68	134.18
Res/Com Total	461.33	969.06	1,073.07	906.44	1,268.00	1,151.82	1,124.07	6,953.79

Source: Navigant analysis of CPUC Standard Program Tracking Database. 2014 (includes HVAC Interactive Effects)

Table A-3: SDG&E Electric Detailed Calibration Inputs by Sector, End-Use, and Year (GWh)

Sector End-Use	2006	2007	2008	2009	2010	2011	2012	2006-2012 Total
Residential	55.38	177.31	120.23	142.49	136.62	189.18	243.31	1,064.52
AppPlug	8.69	18.88	16.74	17.40	14.22	9.21	7.29	92.42
BldgEnv	0.10	0.18	0.25	0.24	0.16	0.14	0.18	1.26
HVAC	0.10	1.46	1.58	3.87	1.26	2.29	1.49	12.05
Lighting	46.47	156.77	97.68	106.50	119.40	176.94	233.92	937.67
NA	0.00	0.00	0.00	0.00	0.00	0.36	0.20	0.55
SHW	0.01	0.03	3.98	10.15	0.01	0.01	0.10	14.29
WholeBlg	0.00	0.00	0.00	4.32	1.58	0.24	0.13	6.27
Commercial	72.80	135.75	188.65	294.72	87.11	82.27	131.21	992.50
AppPlug	0.56	1.42	5.88	6.05	4.96	0.47	7.41	26.76
BldgEnv	0.14	1.02	0.61	0.52	0.89	0.20	0.27	3.64
ComRefrig	4.00	5.27	8.21	9.64	11.42	10.97	12.25	61.76
FoodServ	0.03	3.22	0.18	2.07	0.23	0.99	0.84	7.55
HVAC	6.85	45.45	45.10	46.07	23.59	26.18	36.51	229.76
Lighting	54.60	72.14	121.82	183.73	38.80	34.93	57.11	563.13
NA	0.92	4.09	5.63	30.08	5.45	7.66	10.67	64.50
ProcHeat	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04
Service	0.00	0.78	0.29	4.00	1.61	0.80	6.04	13.52
SHW	0.00	0.08	0.88	1.77	0.09	0.02	0.11	2.93
WholeBlg	5.70	2.28	0.07	10.79	0.07	0.00	0.00	18.90
Res/Com Total	128.18	313.06	308.88	437.20	223.73	271.45	374.52	2,057.02

Source: Navigant analysis of CPUC Standard Program Tracking Database. 2014 (includes HVAC Interactive Effects)

A.8 Detailed Gas Calibration Inputs

Table A-4: PG&E Gas Detailed Calibration Inputs by Sector, End-Use, and Year (MM Therms)

Sector End-Use	2006	2007	2008	2009	2010	2011	2012	2006-2012 Total
Residential	-2.81	-7.45	-9.60	-5.67	-8.45	-6.44	-5.87	-46.30
AppPlug	-0.52	-0.93	-0.58	0.44	0.27	0.20	0.18	-0.94
BldgEnv	0.27	0.41	0.52	0.36	1.12	1.04	0.92	4.64
HVAC	0.45	0.68	1.04	0.72	1.04	0.59	0.38	4.89
Lighting	-3.20	-8.12	-11.57	-8.18	-12.41	-9.75	-8.72	-61.95
NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SHW	0.18	0.48	0.61	0.66	1.14	1.16	0.73	4.95
WholeBlg	0.00	0.04	0.39	0.34	0.39	0.32	0.64	2.11
Commercial	1.68	6.95	17.35	5.06	4.12	5.59	4.30	45.06
AppPlug	0.03	0.07	0.16	0.13	0.00	-0.01	0.02	0.40
BldgEnv	0.00	0.01	0.02	0.01	0.65	0.28	0.24	1.20
ComRefrig	0.13	0.41	0.02	0.02	0.01	0.02	0.22	0.82
FoodServ	0.08	0.15	0.45	0.22	0.11	0.19	0.30	1.50
HVAC	1.70	7.36	15.52	6.25	1.44	1.91	2.99	37.18
Lighting	-0.80	-1.96	-3.20	-3.44	-1.26	-1.16	-1.63	-13.45
NA	0.03	0.02	1.42	0.14	0.69	2.59	0.40	5.30
ProcHeat	0.19	0.62	1.89	0.98	1.05	0.57	0.76	6.06
ProcRefrig	0.00	0.00	0.00	0.00	0.07	0.02	0.01	0.10
Service	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.87
SHW	0.32	0.29	1.06	0.75	0.50	1.18	0.98	5.08
Res/Com Total	-1.13	-0.50	7.74	-0.61	-4.33	-0.86	-1.57	-1.24

Source: Navigant analysis of CPUC Standard Program Tracking Database. 2014 (includes HVAC Interactive Effects)

Table A-5: SCG Gas Detailed Calibration Inputs by Sector, End-Use, and Year (MM Therms)

Sector End-Use	2006	2007	2008	2009	2010	2011	2012	2006-2012 Total
Residential	1.19	1.67	2.36	4.12	8.52	8.43	7.48	33.79
AppPlug	0.17	0.34	0.48	0.41	0.99	0.77	1.72	4.88
BldgEnv	0.19	0.38	0.35	0.26	0.34	0.33	0.36	2.22
HVAC	0.05	0.16	0.08	0.10	0.73	0.84	0.77	2.73
NA	0.00	0.00	0.00	0.12	0.25	1.32	1.18	2.87
SHW	0.79	0.79	1.44	3.13	6.12	5.14	3.24	20.66
WholeBlg	0.00	0.00	0.00	0.10	0.09	0.04	0.20	0.43
Commercial	6.22	13.69	28.71	20.09	4.86	9.87	15.08	98.52
AppPlug	0.00	0.00	0.47	0.69	0.34	0.23	0.00	1.75
BldgEnv	0.58	0.50	0.46	0.21	0.13	0.03	0.01	1.93
FoodServ	0.05	0.18	0.33	0.54	0.33	0.23	0.29	1.96
HVAC	3.64	8.51	14.38	14.67	0.77	0.58	3.16	45.71
NA	1.53	1.96	9.95	1.09	1.57	1.64	5.18	22.91
ProcHeat	0.25	0.85	0.92	0.33	0.57	1.80	5.02	9.74
ProcRefrig	0.00	0.00	0.00	0.00	0.07	0.01	0.03	0.11
SHW	0.16	1.69	2.20	0.76	0.54	0.59	0.43	6.38
WholeBlg	0.01	0.00	0.00	1.78	0.52	4.75	0.96	8.03
Res/Com Total	7.41	15.36	31.07	24.21	13.38	18.31	22.56	132.31

Source: Navigant analysis of CPUC Standard Program Tracking Database. 2014

Table A-6: SDG&E Gas Detailed Calibration Inputs by Sector, End-Use, and Year (MM Therms)

Sector End-Use	2006	2007	2008	2009	2010	2011	2012	2006-2012 Total
Residential	-0.46	-1.55	0.40	2.12	0.59	-0.40	-2.22	-1.52
AppPlug	-0.12	-0.08	0.82	0.16	0.00	0.20	0.09	1.07
BldgEnv	0.03	0.06	0.07	0.07	0.05	0.05	0.06	0.39
HVAC	0.01	0.05	0.06	0.13	0.17	0.18	0.13	0.74
Lighting	-0.59	-2.03	-1.16	-1.11	-1.45	-2.19	-2.94	-11.47
NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SHW	0.20	0.45	0.61	2.86	1.71	1.31	0.42	7.57
WholeBlg	0.00	0.00	0.00	0.01	0.11	0.04	0.02	0.18
Commercial	1.11	0.84	1.34	3.61	0.85	1.68	4.49	13.91
AppPlug	0.03	0.06	0.05	0.00	-0.06	0.01	0.00	0.09
BldgEnv	0.00	0.00	0.01	0.00	0.09	0.08	0.00	0.18
ComRefrig	0.03	0.03	0.05	0.07	0.04	0.05	0.09	0.37
FoodServ	0.02	0.05	0.05	0.05	0.05	0.09	0.08	0.38
HVAC	0.17	0.56	0.76	1.91	0.31	0.10	1.41	5.22
Lighting	-0.12	-0.17	-0.25	-0.32	-0.04	-0.05	-0.11	-1.06
NA	0.03	0.11	0.17	0.52	0.19	0.93	2.52	4.48
ProcHeat	0.84	0.01	0.00	0.16	0.09	0.22	0.21	1.51
ProcRefrig	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Service	0.00	0.00	0.00	0.00	0.04	0.00	0.11	0.15
SHW	0.02	0.19	0.49	1.18	0.14	0.25	0.19	2.47
WholeBlg	0.10	-0.01	0.00	0.03	0.00	0.00	0.00	0.13
Res/Com Total	0.65	-0.71	1.75	5.73	1.44	1.28	2.27	12.39

Source: Navigant analysis of CPUC Standard Program Tracking Database. 2014 (includes HVAC Interactive Effects)

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Appendix B. Emerging Technologies

The Stage 1 update for Emerging Technologies (ETs) maintained the same measure list as the 2013 Study and focused on only updating the inputs to the 2015 PG Model where the Navigant team had better information or data availability.

ETs are defined as meeting one or more of the following criteria:

- Not widely available in today's market but expected to be available in the next 1-3 years;
- Widely available but representing less than 5% of the existing market share; and/or
- Costs and/or performance are expected to improve in the future.

B.1 Overview of Updates

ETs were only examined for the Residential and Commercial sectors. These sectors are modeled using individual measures for specific applications.

The Navigant team relied on data from various sources to update each ET:

- The Navigant team extrapolated or used directly cost and performance data from DEER where possible. In some cases, some ETs had already been characterized in the DEER database since the 2013 Study. For such cases, the Navigant team continued to call these measures ETs to be consistent with the last study (e.g. 0.98 AFUE Gas Furnace).
- IOU workpapers and other case studies provided additional cost and performance data.
- 2010 – 2012 EM&V studies[69] such as "Work Order 017 Ex Ante Measure Cost Study "provided more California-specific data.
- In absence of any California-specific verified data, the Navigant team leveraged data from national studies published by the U.S. Department of Energy (DOE) and the Pacific Northwest National Lab (PNNL) and adjusted to California specific values based on regulatory and market conditions.
- DOE standards and rulemaking review ensured the maximum technically feasible energy efficiency level for many measures and end uses remained same.
- Energy Star's qualified products list and shipment data provided market saturation data.

While the measure categories remained same, their definitions were updated in some cases to reflect the market conditions more closely where we had better data.

[69] *2010-2012 WO017 Ex Ante Measure Cost Study.*
2010-2012 WO013 Residential Lighting Process Evaluation and Market Characterization.
2010-2012 WO028 California Upstream and Residential Lighting Impact Evaluation.

- LEDs were redefined based on CFL definitions update. LED definitions are linked to CFL definitions, which were updated based on 2010 – 2012 EM&V studies.
- Residential Water heaters were updated from 0.77 Energy Factor (EF) to 0.82 EF due to the addition of 0.82 EF water heater measure to DEER. If a measure with same or higher efficiency than the corresponding ET efficiency was included in DEER since the 2013 Study, Navigant set the minimum efficiency of the ET to match the highest efficiency description in DEER for applicable measures.
- Self-Contained Refrigerator measure was redefined to be 15% less than energy code due to redefinition of Energy Star products.
- Dishwasher measure was redefined to be EF>1.0 compared to previous round, based on code and competing conventional energy efficient measure update.
- Commercial Refrigeration Fiber Optic LED lighting measure was eliminated. Strong LED efficacy and cost improvements have led to LEDs becoming a dominant lighting technology and moving towards large market penetration in commercial refrigeration market. This resulted in nearly no future potential for this particular ET measure, as such, the Navigant team abandoned the measure from Stage 1.

Some ETs (along with some conventional technologies) are expected to decrease in cost over time. The Navigant team developed four cost reduction profiles that could apply to various ETs (and non-ETs) in the 2013 Study (see 2013 Study Appendix A). These cost reduction vectors were qualitatively assigned to each ET based on various market drivers that could drive the cost down. Navigant revised these cost reduction assignments based on the further market intelligence developed for the ET measures since the 2013 study (see Table B-1).

B.2 Updates for LEDs

The Navigant team also updated data on the cost reduction and performance improvement profiles for LED technologies. LED costs have declined rapidly in recent years (a 50% reduction in market average price from 2011 to 2015) and are expected to continue to decrease in the foreseeable future. Meanwhile, LED efficacy has been increasing and is expected to increase over 40% from 2015 to 2024. This efficacy change will continue to decrease the wattage requirements of LEDs in the future. The PG Model reflects both of these trends.

LED efficacies were updated to reflect market average products and LED efficacies have dropped compared to the 2013 Study. Previous data[70] used in the 2013 Study represented the "best performers" in the market which was based on U.S. DOE technology targets and did not represent the majority of products in the market. New data[71] in Stage 1 represents the average performance and cost which are based on historical data for LEDs. Stage 1 also uses efficacy and cost data specific to LED applications (i.e. General Service and Directional), which allowed Navigant to map the efficacy data to each LED measure more precisely. The mapping of each LED measure to its definition and application can be found in Table B-2.

LED costs were also updated to market average products based on the most recent DOE pricing study[72] conducted by PNNL. This study is purely based on bulk purchasing that DOE has done for verification of LED lighting product performance through its CALiPER and Gateway programs. As such, the analysis is not based on catalog pricing and is based on actual LED purchases at volume pricing. The Navigant team determined that this should be a good proxy and would not be inflated pricing.

Then, these LED efficacies and prices were further adjusted to represent LEDs that meet the California Energy Commission's Voluntary Quality LED Lamp Specification[73]. The specifications are based on enhancements to the ENERGY STAR standard with a particular focus on improvements to the color temperature, consistency, and color rendering (with requirements for Color Rendering Index (CRI) greater than or equal to 90). The specification applies to screw-base and bi-pin A-lamp, flame-tip, globe, and spotlight lamps. After December 11, 2013, compliance with the specification for LED lamps became mandatory for IOU incentive program eligibility (this followed a one-year "transition period" that began when the specification came into effect on December 11, 2012).

Navigant leveraged a web-scraped database[74] of pricing and specifications for over 15,000 LED lighting products time-stamped between 2008 and 2014 for developing CRI adjustment factors. Major data sources include Home Depot, Lowes, Target, Walmart, Grainger, BestBuy, CALiPER, Gateway, GSA

[70] Navigant. *Energy Savings Potential of Solid-State Lighting in General Illumination Applications.* Prepared for the U.S. Department of Energy, January 2012.
[71] Navigant. *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications.* Prepared for the U.S. Department of Energy, August 2014.
[72] Pacific Northwest National Laboratory. *Solid-State Lighting Pricing and Efficacy Trend Analysis for Utility Program Planning.* Prepared for the U.S. Department of Energy, October 2013.
[73] http://www.energy.ca.gov/2012publications/CEC-400-2012-016/CEC-400-2012-016-SF.pdf
[74] Navigant Web-Scrape LED Product Database

Advantage, Platt, ACE Hardware, Amazon.com, and 1000bulbs.com. This extensive resource of data enables the development of LED price estimates for a variety of product categories ranging from LED lamps (A-line, Globe, decorative, BR, PAR, R, MR, etc.) to luminaires (downlights, track fixtures, surface mounted/recessed troffers, panels, high/low bay, etc.) to outdoor fixtures. The database also holds a variety of information on each product entry including wattage, lumen output, CCT, CRI, voltage, dimmability, Energy Star qualified, and number of product reviews.

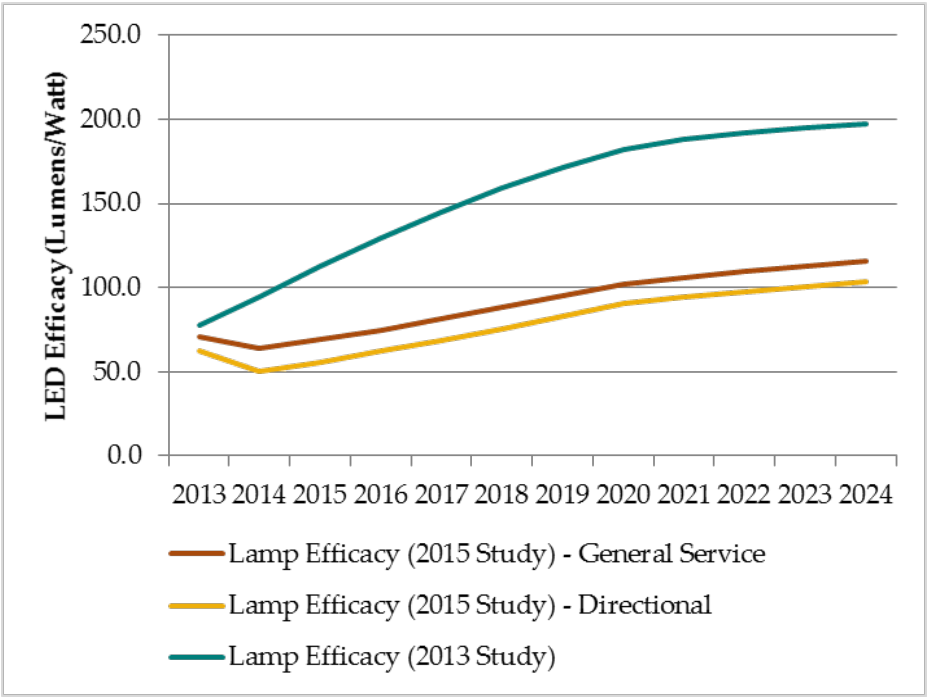
From this dataset the Navigant team analyzed how variations in LED performance affect LED efficacy and selling price. This ability enabled the team to evaluate the efficacy and the price premium associated with LEDs that meet the California Energy Commission's Voluntary Quality LED Lamp Specification.

Although the CPUC Ex Ante Measure Cost Study examined some LED technologies, the information contained in the report was collected in 2013 and is already obsolete because of the rapid evolution of the LED market

The current database includes location specific data for California and these data were analyzed to determine average efficacy and price in 2014 for CRI greater than or equal to 90, compared to CRI less than 90. From this comparison, the Navigant team then developed estimates for the average percentage change in efficacy and price associated with products that offer CRI greater than or equal to 90 for each LED measure.

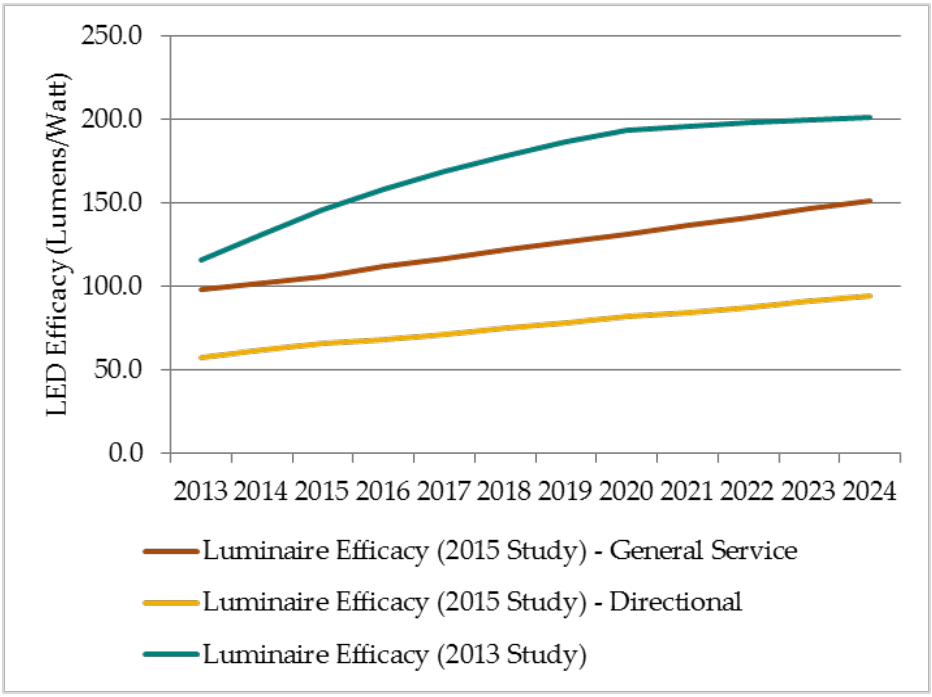
On average efficacies were adjusted by 16-19% and prices were adjusted by 10-12% starting in 2014 with the percentage adjustment decreasing over time to almost 0% by 2020. The Navigant team assumed the average CRI for LEDs in the California market will catch up with the Voluntary Quality LED Lamp Specification over time. As such, in couple years there will be no premium associated with LED products that meet the CRI requirement compared to the DOE study LED efficacies and prices for market average products. Figure B-1 and Figure B-2 illustrate the difference in LED efficacies used in both studies from 2013 to 2024. The small drop in the LED lamp efficacies from 2013 to 2014 shown in Figure B-1 is due to the Voluntary Quality LED Lamp Specification going into effect in 2014. Figure B-3 and Figure B-4 illustrate the difference in LED prices used in both studies from 2013 to 2024. Additional details on which LED measure are General Service and which are Directional can be found in Table B-2.

Figure B-1: LED Technology Improvements (Lamps)



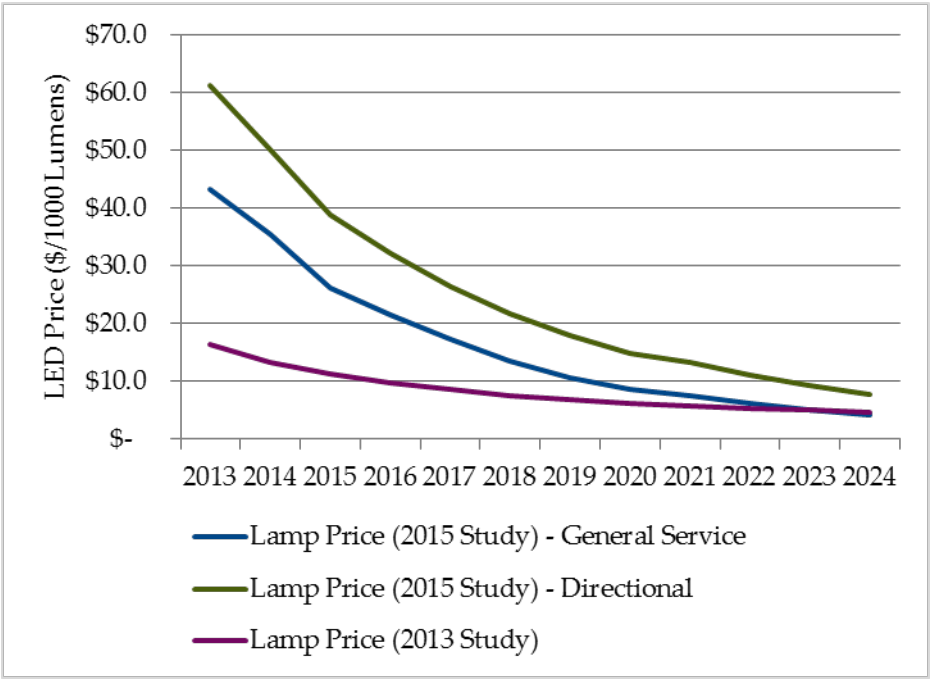
Source: Navigant team analysis 2015.

Figure B-2: LED Technology Improvements (Luminaires)



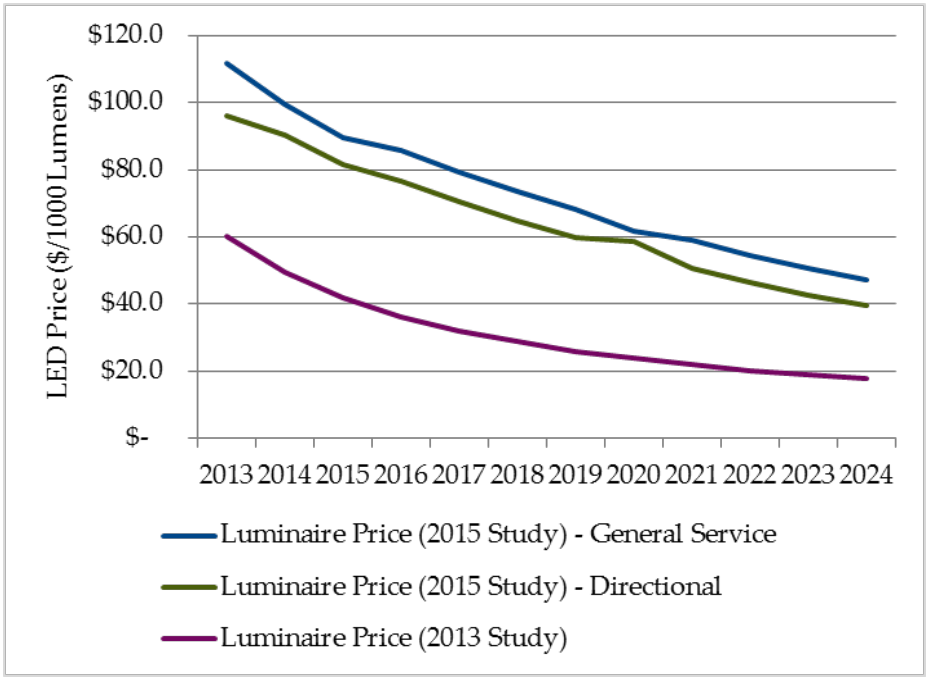
Source: Navigant team analysis 2015.

Figure B-3: LED Cost Reduction Profiles (Lamps)



Source: Navigant team analysis 2015.

Figure B-4: LED Cost Reduction Profiles (Luminaires)



Source: Navigant team analysis 2015.

B.3 Emerging Technology Risk Factor

In the 2013 Study, the Navigant team assigned a risk factor to each ET to account for the inherent uncertainty in the ability for ETs to produce reliable future savings. Actual future adoption of ETs will vary depending on technology. Some ETs may gain large customer acceptance, capture significant market shares, and generate large savings, while others may falter achieving no market share and no savings. It is impossible to pre-determine which ETs will succeed and which will fail. The ET risk factor acts to de-rate the market adoption of each individual ET. The result is a total ET savings value that is representative of what can be expected of the group of ETs. In Stage 1, the Navigant team revised the risk factors based on the same qualitative metrics that were used previously which included market risk, technical risk, and data source risk. The framework for assigning the risk factor is shown in the 2013 Study.

Navigant's logic for revising the risk factors was based on the success of the measure meeting one or more of the following criteria since the 2013 Study:

- Has overcome some of the market barriers identified previously;
- Has established strong distribution channels;
- Has resolved remaining technology issues; and
- Has produced evaluated energy savings that are equal to current (unevaluated) savings claims.

B.4 Emerging Technology Key Descriptors

Table B-1 lists the emerging technologies included in this study along with their descriptions, market introduction year, applicability, and risk factor and technology improvement parameters.

Table B-2 maps LED technologies to their measure description, LED type, and proxy LED market technology.

Table B-1: Measure Level Details of ETs Included in the 2015 Potentials and Goals Study

Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile	Efficient Consumption Reduction Profile
RES	Electric	Clothes Washer All Sizes, Electric DHW, Electric or Gas Dryer - Average MEF = 2.87, Average Capacity = 2.93 Gallons	Clothes Washer All Sizes, Electric DHW, Electric or Gas Dryer - Average MEF = 0.78, Average Capacity = 2.93 Gallons	2012	100%	20%	Low	None
RES	Gas	Clothes Washer All Sizes, Gas DHW, Electric or Gas Dryer - Average MEF = 2.87, Average Capacity = 2.93 Gallons	Clothes Washer All Sizes, Gas DHW, Electric or Gas Dryer - Average MEF = 0.78, Average Capacity = 2.93 Gallons	2012	100%	20%	Low	None
RES	Electric	Energy Star® Dish Washer - Standard Size w/Electric Water Heater - 160 Cycles per Year - EF = 1.0	Dish Washer - Standard Size w/Electric Water Heater - 160 Cycles per Year - Average EF = 0.45	2012	100%	30%	Low	None
RES	Gas	Energy Star® Dish Washer - Standard Size w/Electric Water Heater - 160 Cycles per Year - EF = 1.0	Dish Washer - Standard Size w/Gas Water Heater - 160 Cycles per Year - Average EF = 0.45	2012	100%	30%	Low	None
RES	Electric	Heat Pump Electric Clothes Dryer	Average Market Baseline Clothes Dryer	2016	100%	50%	Medium	None
RES	Electric	Emerging Tech Refrigerator - 15% less energy than code	Code Refrigerator	2012	60%	35%	Low	None
RES	Electric	Home office - Smart Strip with one control outlet, four controlled outlets, and two constant outlets	Power Strip	2008	100%	25%	Medium	None
RES	Electric	Home theater - Smart Strip with one control outlet, four controlled outlets, and two constant outlets	Power Strip	2008	100%	25%	Medium	None
COM	Electric	Advanced Rooftop Unit AC, EER 12, COP 3.52, Advanced Economizer and Controls	Package EER Rated dxAC - Average EER = 9.68	2014	100%	45%	Medium	None
COM	Electric	Energy Recovery Ventilation system for commercial HVAC	No Energy Recovery Ventilation system	2009	12%	50%	Medium	None

Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile	Efficient Consumption Reduction Profile
RES	Gas	Furnace Upgrade to Efficient Furnace - Average AFUE = 98	Base Case Furnace - Average AFUE = 76.8, Average HIR = 1.25	2015	100%	10%	Low	None
RES	Electric	22 SEER Split-System Air Conditioner	Residential SEER-rated split Air Conditioners, 18-65 kBTU/h; pre-2001: SEER = 10 (EER = 8.52), one-speed fan; post-2001: SEER = 13 (EER = 11.08), one-speed fan; 2014: SEER = 14 (EER = 11.82), one-speed fan	2015	100%	20%	Medium	None
RES	Electric	Split SEER-Rated Heat Pump - Average SEER = 21	Res SEER-Rated Splt HP, 7.1-3.01 kBTU/h; pre-2001: SEER = 10 (HSPF = 7.1), one-speed fan; post-2001: SEER = 13 (HSPF = 8.2), one-speed fan; 2014: SEER = 14 (HSPF = 8.2), one-speed fan	2015	100%	20%	Medium	None
COM	Electric	LED fixture: 33W, 3500 lumens	LF fixture: T8, 48inch, 32W lamp (2), Total fixture Watts = 59; Ballast specs: Instant Start, Electronic, NLO, 2 per lamp; Lamp specs: 3175 lumens, CRI=70, rated hours = 20000	2011	100%	20%	LED Luminaire - General Service	LED Luminaire - General Service
COM	Electric	LED interior lamp: 24W, 1700 lumens	Indoor Incandescent Lamp (Screw-In >= 25W) - Average Lamp Watts = 131.89W, Average Lamp CFL Ratio = 0.357	2011	100%	25%	LED Lamp - Directional	LED Lamp - Directional
RES	Electric	LED Screw-In Indoor Lamp: 16.5W, 1300 lumens	Incandescent, Screw-In Indoor 81.5W	2011	100%	25%	LED Lamp - Directional	LED Lamp - Directional
RES	Electric	LED Screw-In Outdoor Lamp: 16.5W, 1200 lumens	Incandescent Screw-In Outdoor, 87W	2011	100%	25%	LED Lamp - Directional	LED Lamp - Directional
COM	Electric	LED interior lamp: 11W, 900 lumens	Indoor Incandescent Lamp (Screw-In < 25W) - Average Lamp Watts = 58.13W, Average Lamp CFL Ratio = 0.357	2011	100%	20%	LED Lamp - General Service	LED Lamp - General Service

Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile	Efficient Consumption Reduction Profile
RES	Electric	LED Screw-In Indoor Lamp: 8W, 675 lumens	Incandescent Screw-In Indoor, 46W	2011	100%	20%	LED Lamp - General Service	LED Lamp - General Service
RES	Electric	LED Screw-In Outdoor Lamp: 9W, 700 lumens	Incandescent Screw-In Outdoor, 57W	2011	100%	20%	LED Lamp - General Service	LED Lamp - General Service
RES	Electric	LED Screw-In Indoor Reflector Lamp: 12W, 850 lumens	Incandescent Screw-In Indoor, 71.5W	2011	100%	20%	LED Lamp - Directional	LED Lamp - Directional
RES	Electric	LED Screw-In Outdoor Reflector Lamp: 14W, 1000 lumens	Incandescent Screw-In Outdoor, 76W	2011	100%	20%	LED Lamp - Directional	LED Lamp - Directional
RES	Electric	LED Screw-In Indoor Specialty Lamp: 10W, 780 lumens	Incandescent Screw-In Indoor, 42W	2011	100%	20%	LED Lamp - General Service	LED Lamp - General Service
RES	Electric	LED Screw-In Outdoor Specialty Lamp: 11W, 870 lumens	Incandescent Screw-In Outdoor, 38W	2011	100%	20%	LED Lamp - General Service	LED Lamp - General Service
COM	Electric	LED interior fixture: 14W, 900 lumens	Incandescent interior fixture 98.8W	2011	100%	20%	LED Luminaire - Directional	LED Luminaire - Directional
RES	Electric	LED Indoor Fixture: 10W, 650 lumens	Incandescent Indoor Fixture, 79W	2011	100%	20%	LED Luminaire - Directional	LED Luminaire - Directional
RES	Electric	LED Outdoor Fixture: 10W, 700 lumens	Incandescent Outdoor Fixture, 114W	2011	100%	20%	LED Luminaire - Directional	LED Luminaire - Directional
COM	Gas	Condensing Small Gas Storage Water Heater with low Nox burner - Average Size = 51 Gal, Average EF = 0.77	Multiple base efficiency levels used, example: Small Gas Storage Water Heater - Average Size = 51 Gal; Average EF = 0.57; Average Recov Eff = 0.76	2015	80%	50%	Low	None

Sector	Fuel Type	Efficiency Measure	Base Case Description	Measure Market Introduction Year	Technology Applicability	Risk Factor	Cost Reduction Profile	Efficient Consumption Reduction Profile
RES	Gas	Small Gas Storage Water Heater - Average Size = 51 Gal, Average EF = 0.82	Small Gas Storage Water Heater - Average Size = 51 Gal; Average EF = 0.561; Average Recov Eff = 0.76	2015	100%	25%	Low	None
COM	Gas	Condensing Large Gas Storage Water Heater - Average Et = 0.99	Multiple base efficiency levels used, example: Large Gas Storage Water Heater; Et = 0.80; Stdby Loss = 0.56%/hr	2012	100%	30%	Low	None

Table B-2: LED Mapping

LED Mapping					
NEW Measure Name	Sector	Efficiency Measure	LED Type	LED Mapping	Market Proxy
Lighting - LED Lamp (Basic High - Indoor) - Emerging	Com	LED interior lamp: 24W, 1700 lumens	Lamp	Directional	LED R, BR, PAR Lamp
Lighting - LED Lamp (Basic Low - Indoor) - Emerging	Com	LED interior lamp: 11W, 900 lumens	Lamp	General Service	LED A-type Lamp
Lighting - LED Fixture (Replacing T8) - Emerging	Com	LED fixture: 33W, 3500 lumens	Luminaire	General Service Linear Fix.	LED Troffer Fixture
Lighting - LED Plug-In Indoor Fixture - Emerging	Com	LED interior fixture: 14W, 900 lumens	Luminaire	Directional	LED Downlight + Track
Lighting - LED Lamp (Basic High - Indoor) - Emerging	Res	LED Screw-In Indoor Lamp: 16.5W, 1300 lumens	Lamp	Directional	LED R, BR, PAR Lamp
Lighting - LED Lamp (Basic Low - Indoor) - Emerging	Res	LED Screw-In Indoor Lamp: 8W, 675 lumens	Lamp	General Service	LED A-type Lamp
Lighting - LED Lamp (Basic High - Outdoor) - Emerging	Res	LED Screw-In Outdoor Lamp: 16.5W, 1200 lumens	Lamp	Directional	LED R, BR, PAR Lamp
Lighting - LED Lamp (Basic Low - Outdoor) - Emerging	Res	LED Screw-In Outdoor Lamp: 9W, 700 lumens	Lamp	General Service	LED A-type Lamp

Lighting - LED Plug-In Indoor Fixture - Emerging	Res	LED Indoor Fixture: 10W, 650 lumens	Luminaire	Directional	LED Downlight + Track
Lighting - LED Plug-In Outdoor Fixture - Emerging	Res	LED Outdoor Fixture: 10W, 700 lumens	Luminaire	Directional	LED Downlight + Track
Lighting - LED Lamp (Reflector - Indoor) - Emerging	Res	LED Screw-In Indoor Reflector Lamp: 12W, 850 lumens	Lamp	Directional	LED R, BR, PAR Lamp
Lighting - LED Lamp (Reflector - Outdoor) - Emerging	Res	LED Screw-In Outdoor Reflector Lamp: 14W, 1000 lumens	Lamp	Directional	LED R, BR, PAR Lamp
Lighting - LED Lamp (Specialty - Indoor) - Emerging	Res	LED Screw-In Indoor Specialty Lamp: 10W, 780 lumens	Lamp	General Service	LED MR16
Lighting - LED Lamp (Specialty - Outdoor) - Emerging	Res	LED Screw-In Outdoor Specialty Lamp: 11W, 870 lumens	Lamp	General Service	LED Other

Appendix C. AIMS Sectors

C.1 Industrial

The Navigant team considered the full range of inputs for the Industrial sector to determine where new data sources exist and where existing data sources received significant updates since the 2013 Study. The following sections provide details on those update activities.

Industry Standard Practices

The Stage 1 update effort for the Industrial sector incorporated ISPs issued by the CPUC (approved for Study consideration) into the existing structure. Navigant engaged the CPUC Ex Ante Team to understand the studies for consideration. Initially, Navigant began by identifying all studies related to or partially related to ISP study efforts (i.e., risk assessment studies completed by the IOUs). Table C-1 shows the various sources initially identified by Navigant.

Mapping Industry Standard Practices

For the ISP studies deemed eligible for consideration, Navigant mapped these into the inputs structure initially developed in the 2013 Study. That is, each of the 11 ISP studies were viewed against the 273 assessment recommendation codes (ARCs) that define the measures that inform the Industrial sector potential. See the IAC database manual for additional detail[75] and the 2013 Study Appendix for details on how Navigant initially used these inputs.

Navigant's engineering team vetted each ISP study from the list of eleven (see Table C-2) to identify the associated equipment, measure activities under review, and the related Industrial subsectors where the ISP consideration pertained.

- First the team reviewed the list of 273 ARCs to estimate if the particular study would interact with a given IAC assessment recommendation. The ARC descriptions of measures are somewhat limited, but the Navigant team leveraged the ARC hierarchy scheme to confirm if an ISP study was relatable. For example, ARC 2.2622 includes the following hierarchal descriptions:
  - 2.2: Thermal systems
  - 2.26: Cooling
  - 2.262: Chillers and refrigeration
  - 2.2622: Replace existing chiller with high efficiency model
- These ISP studies often only identify a subsector or industrial area by qualitative descriptions (e.g., "automotive, medical, or packaging manufacturers"). However, Navigant related these ISP studies to subsectors, as defined by the 2013 Study, which rely on North American Industry Classification System (NAICS) codes. The team typically assigned each ISP by three digit NAICS

[75] Industrial Assessment Center. The IAC database manual. Last accessed April 2015. http://iac.rutgers.edu/manual_database.php.

(e.g., NAICS 325 for Chemical manufacturers).

- Next, for those ISP studies that Navigant linked to a subsector and ARC within the Study scope the team reviewed the studies to understand the ISP claims. That is, Navigant reviewed conclusions to understand if an ISP position existed or if one was not found through the study. Navigant further reviewed study findings for specific conditions or scenarios where ISPs do or do not exist. For example, a study might conclude that ISP exists only for new construction or only for facilities in certain regions. For these instances, Navigant estimated the impact on a given subsector as whole. A new construction ISP would generally be estimated to have negligible impact on a subsector and therefore excluded from consideration for the updates.

Navigant's full review of the ISPs found that they generally fell into one of five categories:

1. ISP established by the given study and incorporated into Industrial inputs (2 studies).
2. A study related to the Industrial sector inputs, but the study did not conclude an ISP existed. Therefore, the team did not incorporate any ISP de-ratings into Industrial inputs (1 study).
3. ISP study relates to another sector; the Mining (oil and gas extraction) sector for these instances (4 studies).
4. ISP study relates to a sector outside of the AIMS PG Study scope; e.g., wastewater treatment or parking garage ventilation fans (2 studies).
5. ISP study is highly specific and there are no relatable ARCs (2 studies); Navigant concludes that the ISPs' impact on potential is negligible given the high specificity.

Through the mapping exercise, Navigant related three studies to three ARCs from the list of 11 ISP studies initially identified for the Industrial sector and approved for consideration by the CPUC. Table C-1 shows the results of the mapping exercise and these studies can be found on the CPUC's ISP website.[76]

[76] Ibid, CPUC ISP list.

Table C-1: Industry Standard Practice Studies Initially Identified for 2015 Potential and Goals Study – Stage 1

Study Category	Source	Author/Authority	Number Initially Identified	Number Used
Finalized ISP Studies (Industrial sector)	Energy Division Ex Ante Team	CPUC/Itron, CPUC/PG&E, PG&E, SCE, SCG, SDG&E	11	3
Non-Final or Pending ISP Studies (Industrial or Commercial sectors)	Energy Division Ex Ante Team	CPUC/SCG, PG&E, SCE, SDG&E	9	0
Other Finalized ISP Studies (Commercial sector)	Energy Division Ex Ante Team	CPUC, SCE	1*	0
Risk Assessment Studies	SCE/ASWB Engineering	SCE/ASWB Engineering	34 (excluding 6 studies identified and accounted for by Ex Ante Team)	0
Total			55	3

Source: Navigant team analysis of various ISP and risk assessment studies (2015)

**Navigant initially identified only one study that related to the Commercial sector when in fact it was found later in the update effort that one of the 11 Industrial ISP studies also related to the Commercial sector.*

With CPUC guidance, Navigant screened the list to include only those finalized ISP studies (Industrial sector) that had been developed through the Energy Division Ex Ante Team and deemed viable by the CPUC for use in the 2015 update. That is, the 11 studies shown in the first row of Table C-1. For example, Navigant explored a range of studies and risk assessment reports, and these were ultimately excluded from this specific effort. CPUC considered these risk assessment studies as lower rigor efforts that support rebate eligibility decisions that are not applicable for this Potential Study. CPUC posted completed studies online for reference.[77] Table C-2 shows the studies within the initial scope of consideration.

The Stage 2 effort will continue the discussion with the CPUC and stakeholders to determine how the ISP study process can be refined to better support the needs of potential forecasting, and to assess how to best use lower rigor risk assessments and other market data.

[77] Navigant reviewed a total of 11 studies deemed eligible for consideration by the CPUC. Nine of those studies are posted online. ISP positions are stated for the remaining two and Navigant reviewed those, but formal reports have not yet been prepared and posted online yet. Ibid, CPUC. ISP List.

Table C-2: Industry Standard Practice Studies Mapping Exercise

Study Title	ISP Mapped to Industrial Sector?	Considerations (or reasons for exclusion)
Oil Pipeline Pump Motor VFDs	No	Accounted for in Mining sector.
CO Demand Control Ventilation for Enclosed Parking Structures - VFD Airflow Modulation	No	Commercial related, parking structures that are not specifically targeted by the Industrial sector.
Industry Standard Practice for Outdoor Steam Pipe Insulation for Oil-fields in California	No	Accounted for in Mining sector.
Cement Industry Standard Practice to Add a Percentage of Limestone During Grinding	No	Not included. ISP is extremely specific and the measure inputs do not account for this specific application/measure. Estimating the application of this ISP would result in negligible impacts on Industrial potential.
Juice Tank Insulation	Yes, but no ISP concluded	IAC ARC: *Use economic thickness of insulation for low temperatures.*
Injection Molding Machine Industry Standard Practice Study	Yes	IAC ARC: *Replace hydraulic/pneumatic equipment with electric equipment.*
Industry Standard Practice Assessment For Artificial Lift Pump Control Technologies	No	Accounted for in Mining sector.
Almond Drying Exhaust Air Recirculation Summary*	Yes	IAC ARC: *Utilize outside air instead of conditioned air for drying.*
Oilfield WW Pump Controls Summary_v1_Sanitized*	No	Accounted for in Mining sector.
Wastewater Treatment Plant Pumps VFD - v1	No	Wastewater facility related, not specifically targeted by the Industrial sector.
Low-Rigor ISP Study on Thermal Oxidizers in Plastic Bag Industry	No	Not included. ISP is extremely specific and the measure inputs do not account for this specific application/measure. Estimating the application of this ISP would result in negligible impacts on Industrial potential.

Source: Navigant team analysis of CPUC approved ISP studies (2015)
**Final report drafts of these studies are currently not available on the CPUC website.*

Applying New ISPs to Model Structure

Navigant updated the inputs developed with the 2013 Study structure to incorporate these new ISPs, namely, the studies related to injection molding and almond drying exhaust air recirculation (while the third study on juice tank insulation is excluded because no ISP was found from that study effort). Specifically, Navigant updated the de-rating factors estimated in the 2013 Study for the associated ARCs: 2.4324 and 2.2711. The de-rating factors from the 2013 Study apply to the entire industry whereas these ISP findings apply to the ARCs only for a given portion of Industrial subsectors. Therefore in order to make these recent ISP findings relatable, Navigant conducted the following steps:

- **Measure Equipment Densities:** Navigant reviewed ARCs against subsectors to estimate measure equipment densities. Measure equipment densities are an estimate of the measure densities, or saturations, and are the product of two parameters.
  - **Measure applicability (or total technology density):** As an example for the almond drying exhaust air recirculation ISP study: Navigant estimated that the identified ARC, ARC 2.2711, relates only to six of the 15 established subsectors.
  - **Baseline density:** The Navigant team of expert engineers estimated the saturation of baseline equipment (or the portion of equipment that could be converted to efficient equipment). This is, about 50 percent of the related equipment are at the baseline efficiency level for the given example.
  - **Combining the two parameters:** In terms of energy consumption for the example, Navigant's analysis estimated that ARC 2.2711 relates to only approximately 18 percent of the consumption associated with process cooling and refrigeration end-uses. This is the measure equipment density associated with the ARC.
- **ISP Multiplier:** Continuing the example for ARC 2.2711 and the exhaust air ISP, Navigant's analysis found that the ISP study only relates to the Food subsector (NAICS 311 and 312). Therefore, ARC 2.2711 should only be de-rated for the Food subsector. When considering each subsector's energy consumption, this exercise results in an Industrial sector ISP multiplier of 83 percent for this ARC.
- **Updated De-rate Factor:** The measure equipment density and ISP multiplier are then combined to estimate the new de-rate factor. From the previous example: 18 percent multiplied by 83 percent to arrive at a 15 percent de-rate factor. That is, 15 percent of the original savings reported within the IAC database are applicable to the California market. This value is uploaded into the Industrial inputs and replaces the de-rate factor established during the 2013 Study for ARC 2.2711.

Table C-3 shows the results of this exercise. The list only contains three ISP studies and related ARCs and only two de-rating factor updates. However, Navigant applied the review process to the full list of ISP studies and ARCs to confirm applicability. Further, this analysis approach developed during this 2015 Study can be redeployed for future potential study efforts and after the issue of new ISP studies if the current model framework remains.

Table C-3: Results of the Derating Factor Update Exercise

Study Title	IAC ARC	Application?	Applicable Subsectors (NAICS)	Measure Equipment Density	ISP Multiplier	De-rating Factor
Juice Tank Insulation	2.2516: Use economic thickness of insulation for low temperatures.	Not ISP (only ISP for new construction); not applied to ARC	Food (311, 312)	N/A, not ISP and no updates applied (relying on 2013 de-rating value)		
Injection Molding Machine Industry Standard Practice Study	2.4324: Replace hydraulic/pneumatic equipment with electric equipment.	Applied to ARC	Electronics (334, 335) Chemicals (325) Plastics (326) Transportation Eq. (336) Other (339)	0.500	0.536	0.268
Almond Drying Exhaust Air Recirculation Summary	2.2711: Utilize outside air instead of conditioned air for drying.	Applied to ARC	Food (311, 312)	0.184	0.828	0.152

Source: Navigant team analysis (2015)

Vetting and Density Review Exercise

As mentioned in the previous exercise, the Navigant team, including engineers from ASWB Engineering, reviewed the list of 273 ARCs to vet their applicability to the California market. This vetting exercise reviewed ARCs in terms of measure equipment densities. Navigant conducted this analysis task in response to stakeholder comments and concerns raised about the IAC database being a national level database and not for California specific data. Navigant conducted quantitative reviews for similar comments received during the 2013 Study, and those details can be found in the 2013 Study Appendix G and Appendix T. This current effort built on that 2013 Study work and augment findings with additional expertise from team members familiar with the California Industrial sector and IOU program activities and eligibility requirements.

Navigant's review identified instances where certain ARCs were not fully applicable to California (e.g., cold climate IAC ARCs not applicable in California's milder climate, etc.) or where California or Federal regulations make certain ARCs ineligible (e.g., OSHA requirements for hot surface insulation). Also, the team reviewed ARCs in consideration of California energy efficiency program requirements to identify instances were ARCs are not eligible due to programmatic constraints such as restrictions on maintenance improvements and combined heat and power (CHP) measures.

The results of this exercise confirmed the de-rating factors established for the list of 273 ARCs during the 2013 Study effort.

Preserving 2013 Study De-rating Factors

Finally, after confirming the validity of the 2013 de-rating inputs Navigant updated the values with the recent findings from the ISP review and mapping exercise. Of the 273 ARCs that inform the Industrial potential model Navigant only updates two values as shown in Table C-4 while the remainder were left unchanged from the 2013 study.

Table C-4: Updated De-rating Factors

ARC Description	ARC	2013 De-rating Factor	2015 De-rating Factor
Replace hydraulic / pneumatic equipment with electric equipment	2.4324	0.670	0.268
Utilize outside air instead of conditioned air for drying	2.2711	0.667	0.152

Source: Navigant team analysis (2015)

Other Data Reviews and Updates

Navigant reviewed the other data sources that inform the Industrial inputs to determine where updates to information were warranted. The following subsections provider further details.

Industrial Assessment Center Database

The 2013 Study relied on IAC database records from 2004 to 2012; 2012 is the most recent year with available data. For Stage 1 the Navigant team reviewed the IAC database updates and found additional recommendations made at facilities and recorded in the database for years 2013 and 2014. For those two additional years the IAC added approximately 9,000 measures. Navigant conducted a sensitivity analysis to understand the change in average savings per ARC resulting from the addition of the new data. Table C-5 provides the details of those findings.

Average electric and gas savings per measure (per ARC), as a percent of facility consumption, only changed by 0.03 percent and 0.16 percent, respectively. Therefore, Navigant concluded that the overall changes in the IAC database are negligible, and the team excluded these additional measures and preserved the IAC database inputs used for the 2013 Study.

Table C-5: IAC Database Analysis of Updates

ARC Description	Electric ARCs	Gas ARCs
Additional ARCs (recommendations made in 2013 and 2014)	6,294	2,636
Average savings per ARC from 2004 to 2012 dataset (% of facility consumption)	2.73%	6.41%
Average savings per ARC from 2004 to 2015 dataset (% of facility consumption)	2.70%	6.25%

Source: Navigant team analysis (2015)

Subsector Consumption Data: Quarterly Fuel and Energy Report (QFER)
Navigant obtained updated QFER data (new data for years 2012 and 2013) from the CEC to support the Stage 1 updates.[78] These data specify energy consumption by NAICS and Navigant uses these date to estimate subsector distributions. Navigant notes that QFER updates were only available for electric consumption data, and gas consumption data were not available at the time of the update. Also, Navigant did not anticipate significant changes or shifts in NAICS subsector distributions of energy consumption in the Industrial sector. Therefore, Stage 1 relies on the distributions developed for the 2013 Study.

Subsector Forecasts Data: Integrated Energy Policy Report
Navigant also obtained updated IEPR forecasts from the CEC.[79] Similar to the QFER data, only electric forecasts for energy consumption (kWh) and retail rates ($/kWh) were available at the time of the study. Therefore, the team updated electric forecasts for Stage 1, but the gas forecasts remain unchanged from the 2013 Study.

The IEPR Industrial electric consumption forecasts reduced from the 2013 Study and this reflects a correction to account for Publicly Owned Utilities (POUs) that reside within the larger IOU planning areas. For the planning areas in their entirety (i.e., without considering the reduction resulting from excluding POUs), IEPR estimates a decrease in consumption for PG&E and SDG&E, and an increase for SCE.

Table C-6: IAC Database Analysis of Updates

IOUs	As a percent of the 2013 Forecast Value (average for years 2015 to 2024)	
	Excluding POUs	Excluding POUs
PG&E	76.6%	76.3%
SCE	87.9%	93.9%
SDG&E	100%	92.9%

Source: Navigant team analysis (2015)

The CEC also updated retail rate forecasts to show a slight increase for all IOUs except for SDG&E, and Navigant incorporated these into the model.

[78] CEC. Quarterly Fuel and Energy Report. Last accessed April 2015. http://energyalmanac.ca.gov/electricity/web_qfer/
[79] Ibid, IEPR.

Table C-7: IEPR Electric Retail Rate ($/kWh) Forecast Updates and Comparison

IOUs	Average Retail Rate for years 2015 to 2024	
	Excluding POUs	Excluding POUs
PG&E	$0.111	$0.124
SCE	$0.098	$0.115
SDG&E	$0.156	$0.135

Source: Navigant team analysis (2015)

Other California Data

As part of the Stage 1 update vetting activities Navigant performed similar activities carried out during the 2013 Study. These activities included a comparative metrics vetting of the initial model outputs against IOU compliance filing data.[80] In addition to obtaining feedback directly from stakeholders such as the IOU representatives, comparing results to IOU planning generally helps the Navigant team understand if program activities and ISP constraints are appropriately reflected in the model.

C.2 Agriculture

Similar to the Industrial sector, the Navigant team considered the full range of inputs and sources for the Agriculture sector to determine where new data sources exist and where existing data sources received significant updates since the 2013 Study. The Agriculture sector relies on IAC, QFER, IEPR data, DEER, and the Commercial sector Study effort inform the Agriculture sector.

Industry Standard Practices

Navigant reviewed the ISPs explored for the Industrial sector and found that no new CPUC vetted and approved ISPs exist for the Agriculture sector. The Agriculture sector relies on a similar approach as the Industrial sector in that inputs are informed by supply curves that are adjusted with de-rating factors to account for ISPs, program eligibility considerations, and other constraints that prevent programs from claiming savings. While Navigant's review found no new Agriculture-specific ISPs to incorporate into the inputs, the de-rating factors for Stage 1 change from the factors established through the 2013 Study stakeholder process. These factors are developed from a comparison of Industrial incremental market potential model runs where both de-rating factors are included and excluded. Table C-8 shows a comparison of those model runs from Stage 1 and the resulting de-rate factors that are applied to the Agriculture sector inputs. Additional details on the previous factors and on this analysis approach can be found in the 2013 Study Appendix H and Appendix T.

[80] DEER. IOU Compliance Filings. Last accessed March 2015. ftp://ftp.deeresources.com/E3CostEffectivenessCalculators

Table C-8: Derating Factors Applied to the Agriculture Sector Inputs

Fuel	Equipment Measures	O&M Measures
Electric	11.8%	26.0%
Gas	32.8%	39.9%

Source: Navigant team analysis (2015)

Other Data Reviews and Updates

Navigant reviewed the other data sources that inform the Agriculture inputs to determine where updates to information were warranted. These reviews occurred simultaneous to the same reviews conducted for the Industrial sector, and Navigant made similar conclusions with the noted differences in analysis findings. The following subsections provide details on those updates.

Industrial Assessment Center Database

Similar to the review for the Industrial sector, Navigant conducted a sensitivity analysis and concluded that the overall changes in the IAC database are negligible. Therefore, Navigant excluded additional IAC measures and preserved the IAC database inputs used for the 2013 Study.

Subsector Consumption Data: Quarterly Fuel and Energy Report (QFER) and Drought Conditions

Navigant received updated electric consumption data for the Agriculture sector. Updates for gas consumption were not available. Navigant did not anticipate significant changes or shifts in NAICS subsector distributions of energy consumption in the Agriculture sector. However, Navigant identify significant year-over-year changes in sector-wide consumption. Through further investigation, Navigant correlated increased energy consumption with drought condition years.[81] Therefore, instead of relying on the most recent single year of data, Navigant instead developed a drought-adjusted annual average in order to represent typical energy consumption. The potential model relies on typical energy consumption since savings are derived directly as a percent of energy consumption. Basing the model inputs on 2013 data would erroneously imply increased energy efficiency potential during drought conditions. Navigant reviewed QFER historical trends to develop the adjustment factor. Figure C-1 and Table C-9 show the historical data and the drought factor developed from that data.

[81] California Drought Data. USDA. California Drought 2014: Farms. Last accessed March 2015 http://ers.usda.gov/topics/in-the-news/california-drought-2014-farm-and-food-impacts/california-drought-2014-farms.aspx

Figure C-1: Agriculture Sector Historical Consumption[82]

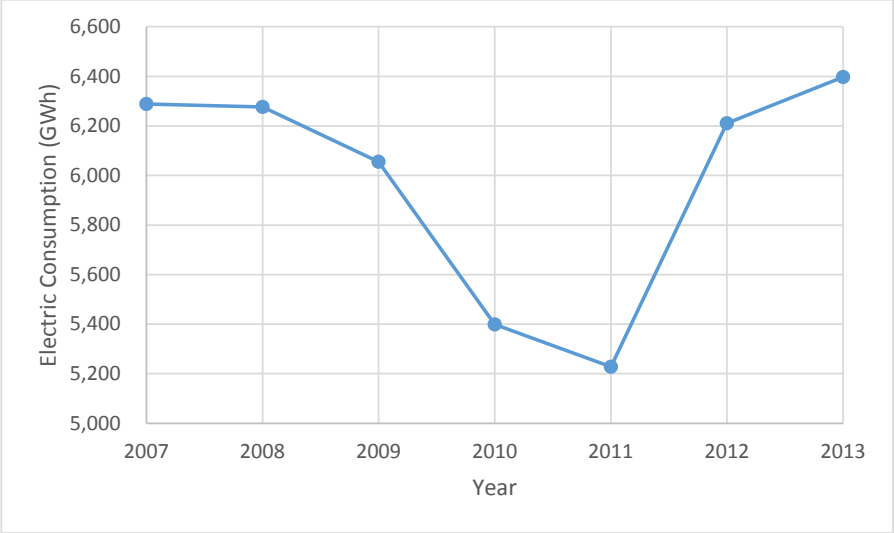


Table C-9: Agriculture Drought Factor[83]

Year	Agriculture Sector Consumption (GWh)	Drought Year?
2007	6,288	Yes
2008	6,277	Yes
2009	6,055	Yes
2010	5,399	No
2011	5,228	No
2012	6,211	Yes
2013	6,397	Yes
Average: 2007-2009 and 2012-13	6,245	Yes
Average: 2010-2011	5,314	No
Drought Factor	0.85	

Source: Navigant team analysis (2015)

Navigant developed drought factors in a similar manner as described in Table C-9 for the individual subsectors/end-uses examined for the Agriculture sector. Ultimately, the drought factors presented in Table C-10 inform the 2015 Potential Study and are applied to the most recent IEPR forecast data that reflects increased energy consumption due to drought conditions. That is, the drought factor reflects the ratio of non-drought conditions to drought conditions (i.e., the average of non-drought QFER year divided by the average of drought QFER years).

[82] Ibid, QFER data.
[83] Ibid, QFER data.

Table C-10: Agriculture Subsector Drought Factors, Electric Consumption[84]

Subsector	Drought Factor	Comments on the Impacts of Drought Conditions[85]
Dairy	90.9%	Increased cooling loads required for livestock and liquid storage.
Irrigated Agriculture	75.0%	Increased pumping energy required to lift water from lower water tables.
Greenhouses and Nurseries	97.8%	Negligible impact; slight cooling load increases expected.
Vineyards and Wineries	77.0%	Increased cooling loads required for liquid storage.
Concentrated Animal Feeding Operations	89.6%	Increased cooling loads required for livestock.
Refrigerated Warehouses	99.5%	Negligible impact; slight cooling load increases expected.
Post-Harvest Processing	94.8%	Minor impact; slight cooling load increases expected for indoor facilities.

Source: Navigant team analysis (2015)

Subsector Forecast Data: Integrated Energy Policy Report

Navigant obtained updated IEPR forecasts.[86] Similar to the Industrial sector, only electric forecasts for energy consumption (kWh) and retail rates ($/kWh) were available at the time of the study. Also, Industrial and Agriculture retail rates are the same (see Table C-7 for changes). The team updated electric forecasts for Stage 1, but the gas forecasts remain unchanged from the 2013 Study.

As previously discussed for the development of the drought factor, Navigant initially reviewed the IEPR electric consumption forecasts for the IOUs and identified a significant increase in the forecast between the 2013 Study inputs and the most recent IEPR release. This increase aligns with the difference seen in QFER data for drought and non-drought years.

[84] Ibid, QFER data.
[85] Based on Navigant's engineering judgment that is also informed by recent MASI Study activities.
[86] Ibid, IEPR data.

Table C-11: Agriculture Subsector Drought Factors, Electric Consumption[87]

Subsector	Drought Factor
2006	100%
2007	100%
2008	100%
2009	101%
2010	98%
2011	87%
2012	106%
2013	114%
2014	115%
2015	116%
2016	117%
2017	117%
2018	118%
2019	119%
2020	120%
2021	121%
2022	122%
2023	123%
2024	125%
2015 to 2024 Average	120%

Source: Navigant team analysis (2015)

Navigant also reduced the IEPR Agriculture electric consumption forecasts to remove POU energy consumption that reside within the larger IOU planning areas. Table C-12 shows the consumption forecasts that reflect the adjustment for drought conditions and exclusion of POUs.

Table C-12: Agriculture IEPR Electric Consumption (kWh) Forecast Updates

IOUs	As a percent of the 2013 Forecast Value (average for years 2015 to 2024)	
	Excluding POUs	Excluding POUs
PG&E	86.1%	91.0%
SCE	62.4%	60.4%
SDG&E	100%	92.9%

Source: Navigant team analysis (2015)

[87] Ibid, IEPR data.

DEER Data

Navigant relied on the same data from the 2013 Study when characterizing gas measures for greenhouses. These data augment the IAC database for the Agriculture sector inputs and include DEER and other analyses developed from secondary sources such as USDA Virtual Grower. DEER serves as the majority source for these measures and Navigant reviewed DEER and found no updated information. Therefore those specific inputs from the 2013 Study remain unchanged.

Commercial MICS

Similar to the DEER data, Navigant also supplemented the Agriculture inputs with sources other than IAC data for HVAC and water heating measures found in winery and vineyard operations. These are sourced from the Potential Study's Commercial sector inputs that include measure details on water heaters and building shell insulation. Navigant did not find any new sources or data to update these commercial measures, and therefore, these inputs for the Agriculture sector remain unchanged from the 2013 Study.

Other California Data

As part of the Stage 1 update vetting activities Navigant performed similar activities carried out during the 2013 Study. These activities included a comparative metrics vetting of the initial model outputs against IOU compliance filing data.[88] Similar to the Industrial sector reviews, comparing results to IOU planning helps the Navigant team understand if program activities and constraints (ISP, programmatic, regulatory, etc.) are appropriately reflected in the model.

C.3 Mining

Similar to the other AIMS sectors, Navigant considered the range of inputs and sources for the Mining sector to determine where new data sources exists and where existing data sources received significant updates since the 2013 Study. Unlike the Industrial and Agriculture sectors, the Mining sector relies on an approach more similar to the Residential and Commercial sectors. Inputs are developed from the bottom up and define specific measures instead of more broadly defined end-uses. Navigant determined that there are no significant updates for certain measure-specific parameters such as baseline and measure level efficiencies or equipment costs. However, Navigant reviewed the range of sources to both vet the 2013 Study inputs as well as identify any new or updated sources to consider that apply to the market more generally such as sector level consumption data.

Industry Standard Practices

Following the analysis of the Industrial sector ISPs, Navigant identified ISPs issued and approved by the CPUC that apply to the Mining sector (and more specifically the oil and gas extraction subsector). During the 2013 Study, Navigant also engaged the CPUC Energy Division (ED) Ex Ante Team for

[88] Ibid, DEER. IOU Compliance Filings.

guidance on how ISPs affect energy efficiency potential within the sector. The ISP studies identified through this recent effort are reflected in the input previously provided by the Ex Ante Team. Table C-13 shows the ISPs related to the Mining sector and how they influence the Potential Study inputs.

Table C-13: Industry Standard Practice Studies Relating to Mining Sector[89]

Study Title	Incorporated into Inputs?	Considerations (or reasons for exclusion)
Oil Pipeline Pump Motor VFDs	No	Midstream surface transport pumps are currently excluded from the Study scope (however, savings from pumps retrofitted with VFDs are de-rated to reflect ISP- see other studies)
Industry Standard Practice for Outdoor Steam Pipe Insulation for Oil-fields in California	Yes	Savings from improvements to steam boiler operations de-rated to reflect ISP
Industry Standard Practice Assessment For Artificial Lift Pump Control Technologies	Yes	Savings from pump-off controller (POC) and VFD installations de-rated to reflect ISP
Oilfield WW Pump Controls Summary_v1_Sanitized*	Yes	Savings from VFD installations de-rated to reflect ISP (new construction in addition to retrofits)

Source: Navigant team analysis (2015)
**Final report drafts of these studies are currently not available on the CPUC website.*

Major and Minor Market Segmentations

Within the oil and gas extraction subsector, ISP considerations are typically a function of organizational size. "Majors" are often subject to more conservative ISP considerations and only "minors" are typically eligible for certain energy efficiency measures. During the 2013 Study Navigant received guidance from the Ex Ante Team that approximately 80 percent of California oil production originated from major producers. This estimate informed the 2013 Study inputs and final Mining sector de-ratings. Navigant confirmed this market bifurcation as part of Stage 1 update by identifying the guidance published by SCE in September 2013 that also sourced guidance from ED. Table C-14 summarizes that guidance. Ultimately, the major-minor market distribution developed for the 2013 Study remains unchanged for Stage 1. Navigant's initial estimate is informed by a review of the 30 largest producers within the state, and the team does not anticipate any significant shifts for that market characteristic in the past two years.

[89] Ibid, CPUC ISP list.

Table C-14: Mining (Oil and Gas Extraction) Major and Minor Market Share Distributions[90]

Designation	Guidance	Market Distribution	Initial ED/CPUC Guidance (2013 Study)	2013 Study Market Distribution; Used for 2015 Study**
Major	Producing more than 2.5% of CA total oil production for 2012*	77%	About 80%	83%
Minor	Producing less than 2.5% of CA total oil production for 2012*	23%	About 20%	17%

Source: Navigant team analysis (2015)
**Approximately 198 MM barrels produced in 2012.*
***This distribution developed through a review of the 30 largest producers within the state.*

Other Data Reviews and Updates

Navigant reviewed the other data sources that inform the Mining inputs to determine where updates to information were warranted. The following subsections provide details on those updates.

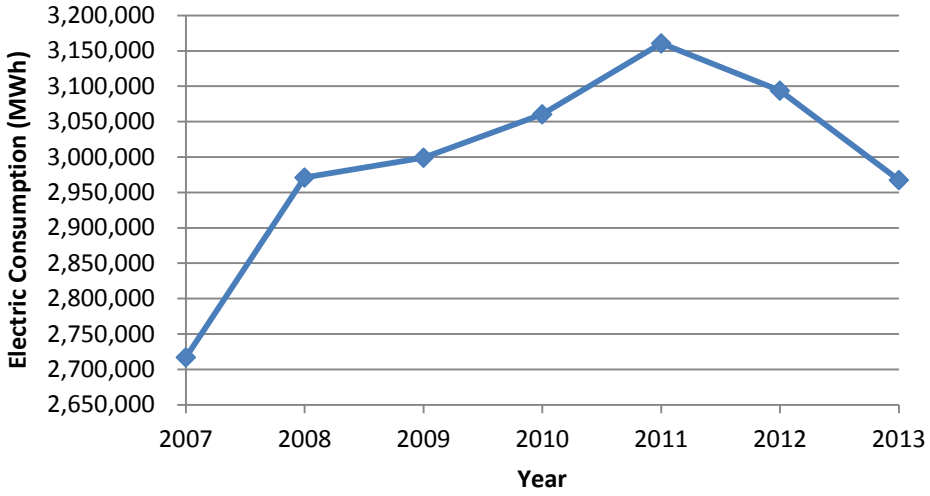
Subsector Consumption Data: Quarterly Fuel and Energy Report (QFER)

Navigant obtained updated QFER data from the CEC to support the Stage 1 updates.[91] For the Mining sector inputs, Navigant relies on the total QFER data to vet the sector-wide roll up of consumption developed as part of the bottoms-up analysis approach. Specifically, Navigant uses the QFER data to vet the equipment stock estimates.

Navigant notes that QFER updates were only available for electric consumption data, and gas consumption data were not available at the time of the update. Consumption for the oil and gas extraction subsector (NAICS 211 and 213) has fallen from 2011 to 2013, but increased overall by 9 percent from 2007 to 2013. Year-over-year changes in consumption reflect production levels that are driven by many factors including economic and regulatory ones. Due to the relatively small changes in sector-wide consumption in recent years Navigant's vetting of QFER data ultimately concluded that no changes to the equipment stocks are warranted.

[90] Oil Industry Major and Minor Company Guidance. Last accessed: April 2015. http://www.caasupport.com/2013/09/oil-industry-major-minor-company-guidance/
[91] Ibid, QFER.

Figure C-2: Oil and Gas Extractor Subsector Electric Consumption (MWh)[92]



Energy Consumption Data Management System

The Mining sector is also informed by the Energy Consumption Data Management System (ECDMS) maintained by the CEC. Navigant uses this data to inform the distribution of sector activity among the IOUs. Similar to the QFER data update, Navigant did not anticipate a significant change in distributions. However, Navigant did apply Stage 1 findings shown in Table C-15 to the inputs. Table C-15 shows ECDMS data for the Mining sector that, in addition to oil and gas extraction, includes mineral mining and construction energy consumption that are currently outside of the scope of the Potential Study. For example, Navigant estimates that the consumption shown in Table C-15 for SDG&E relates only to mineral mining and/or construction.

Table C-15: Mining Sector IOU Consumption Distributions[93]

IOU	Electric Consumption Share (% of IOUs)		Gas Consumption Share (% of IOUs)	
	2013 Study	2015 Study	2013 Study	2015 Study
PG&E	46.5%	48.6%	9.1%	7.1%
SCE/SCG	48.8%	47.4%	90.5%	91.5%
SDG&E	4.7%	4.0%	0.4%	1.4%

Source: Navigant team analysis (2015)

California Department of Conservation Data

Navigant relies on oil and gas extraction statistics published by the California Department of Conservation for a significant portion of the Mining sector inputs. During the 2013 Study Navigant

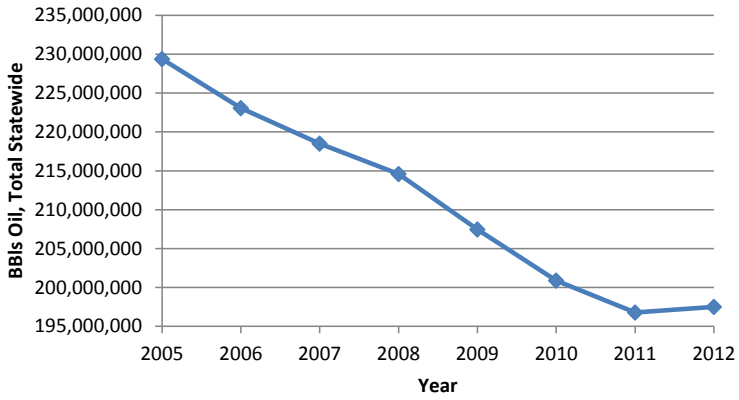
[92] Ibid, QFER data.
[93] CEC. California Energy Consumption Database. Last accessed: April 2015. http://ecdms.energy.ca.gov/

referenced the 2009 Annual Report of the State Oil and Gas Supervisor[94] that included granular details on oil well counts, oil production levels, water production levels, injection (water, steam, other), and several other statistics for specific geographies and individual organizations/operators. Stage 1 referred to the Department of Conservation data again and also identified a 2012 study[95] update as the most recent source. Unfortunately, the most recent publications do not offer the same level of details as the 2009 study. However, Navigant leveraged this new information where it could within the updates, and this included updates to statewide oil production and well counts.

In addition to informing several specific modeling inputs, the California Department of Conservation data generally informs the approach to modeling and characterizing the Mining sector. Well counts are increasing steadily, but production is down and injection activities are up. Further, less oil is being produced, but equal and likely more energy is expended to produce it.

- Oil production levels in California are trending down (Figure C-3).
- Well completions (i.e., new wells created and made ready for use) are steady (Figure C-4).
- Total number of producing wells is trending up (Figure C-5).
- Total volume of injected fluids (i.e., liquid water or steam) is trending up (Figure C-6).

Figure C-3: Statewide Oil Production[96]



[94] CA Dept. of Conservation. 2009 Annual Report of the State Oil and Gas Supervisor. Last accessed: March 2015. ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2009/PR06_Annual_2009.pdf
[95] CA Dept. of Conservation. 2012 Preliminary Report of California Oil and Gas Production Statistics. Last accessed: March 2015. ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2012/PR03_PreAnnual_2012.pdf
[96] Ibid, CA Dept. of Conservation 2009 and 2012.

Figure C-4: Statewide Well Completions[97]

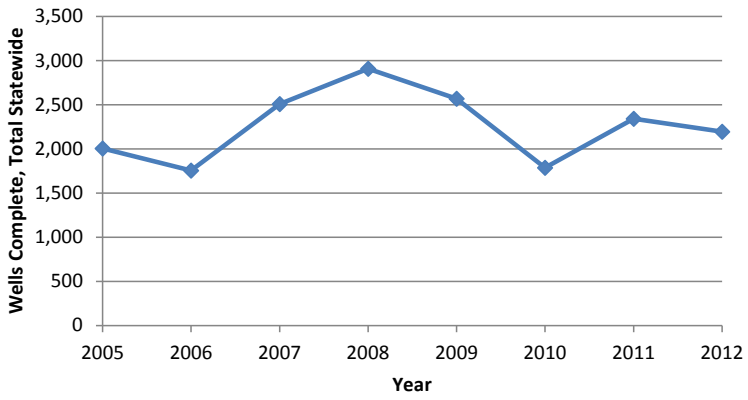
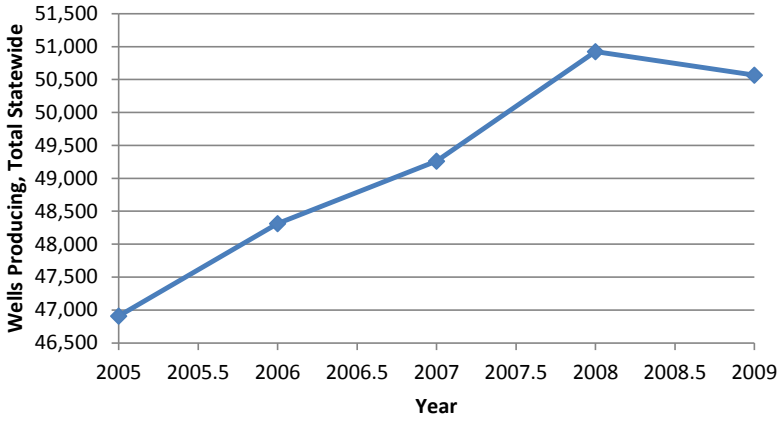
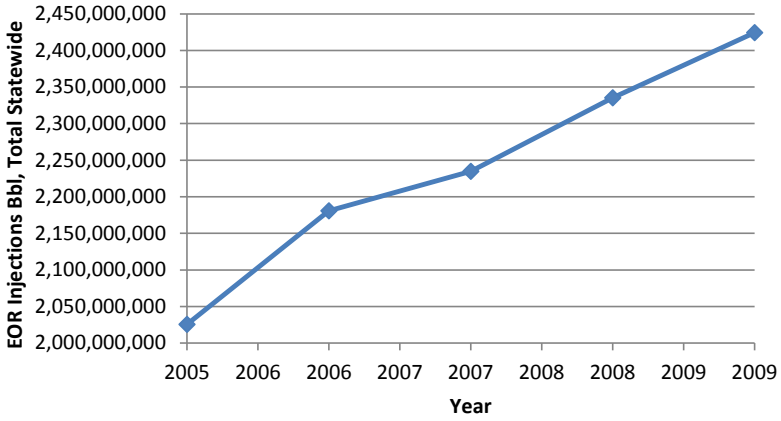


Figure C-5: Statewide Wells in Operation[98]



[97] Ibid, CA Dept. of Conservation 2009 and 2012.
[98] Ibid, CA Dept. of Conservation 2009.

Figure C-6: Statewide Water (steam or liquid) Injection Volumes[99]



Data Vetting

As part of the Stage 1 update vetting activities, Navigant performed similar activities carried out during the 2013 Study. These activities included a comparative metrics vetting of the initial model outputs against IOU compliance filing data.[100]

The Navigant team also reviewed key inputs to conform reasonableness and if any new data sources exists. Team members included subject matter experts familiar with the oil and gas extraction subsector, IOU programs active there, and ISP activities associated with measures within that subsector. These vetting exercises from experts supplement initial input received from other subject matter experts during the 2013 Study. Generally, the 2013 Study inputs reviewed were deemed reasonable and applicable to Stage 1. Therefore, no changes resulted from these reviews.

C.4 Street Lighting

Similar to the other AIMS sectors, Navigant considered the full range of inputs for the Street Lighting sector to determine where new data sources exists and where existing data sources received significant updates since the 2013 Study.

The 2015 Study update generally follows the methodology developed for the 2013 Study. First, Navigant used the IOU-supplied inventories and consumption data from the 2013 Study to estimate baseline and energy efficient measures for customer owned and IOU owned lamps. Sub-sector energy consumption distributions (i.e., street lights, sign lights, traffic lights) were updated from recent QFER data[101] using a bottoms-up approach and triangulated with other consumption data sources. The cost data for LEDs

[99] Ibid, CA Dept. of Conservation 2009.
[100] Ibid, IOU Compliance Filings.
[101] Ibid, QFER data.

were updated based on a forecasting study conducted by the Department of Energy (DOE) in 2014.[102] Navigant also used this study to forecast improvements in efficacies for LEDs.[103] Finally, Navigant recently obtained 2015 Street lighting inventories and consumption data from the IOUs and leveraged this data for vetting these updates.

The majority of updates relate to street lights whereas nominal changes to sign and traffic lights occurred for this update. The following sections primarily relate to street lights and additional details on sign and traffic lights can be found in the 2013 Study Appendix.

IOU Densities and Inventories

The Navigant team reviewed the inventories supplied by the IOUs for the streets subsector. The streets subsector includes incandescent, mercury vapor, low-pressure sodium, high-pressure sodium, metal halide, LED, and induction lamps. Because the Potential Model uses 2013 as a basis year, the Navigant team maintained the 2013 Study distribution of these technologies by lamp count across the subsector while the 2015 distributions supplied by the IOUs provided a calibration point for the Model's output. The 2015 inventories obtained from two IOUs (PG&E and SCE) reflect actual inventories. Secondary sources such as reports on Retrofit Activities for Street Lighting[104] in San Diego and Citywide Broad Spectrum Street Lighting Retrofits[105] by the City of San Diego were used to estimate SDG&E's 2015 inventory.

Similar to the 2013 Study approach, LEDs and induction lamps are considered efficient technologies while the baseline is the current mix of baseline lamp technologies: high-pressure sodium, low-pressure sodium, metal halide, mercury vapor, and incandescent. The Navigant team represented these baseline lamp types with a single lamp based on a weighted average. Estimates for the streets subsector consumption relied on the IOU-provided lamp inventories that are tied to rate schedules (e.g., LS-1 and LS-2) that specify monthly kWh charges.[106]

Per CPUC guidance for the 2015 Study, Navigant accounted for lamp ownership: customer owned versus utility owned. The potential results reflect all lamps, and Table C-16 and Table C-17 can be used to estimate separate potential for customer or IOU owned lamps only.

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[102] DOE. Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. August 2014, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/energysavingsforecast14.pdf

[103] See the Emerging Technology report section for more details.

[104] City of San Diego. Retrofit Activities Summary. Last accessed March 2015 http://www.sandiego.gov/environmental-services/energy/pdf/energysavings.pdf

[105] City of San Diego. Citywide Broad Spectrum Street Lighting Retrofits. Last accessed March 2015. http://www.sandiego.gov/environmental-services/energy/programsprojects/saving/broadspectrumretrofit.shtml

[106] LS-1 and LS-2 Rate Schedules. IOU-specific. Last accessed April 2015.
PG&E: http://www.pge.com/tariffs/ERS.SHTML#ERS
SCE: https://www.sce.com/NR/sc3/tm2/pdf/ce36-12.pdf
SDG&E: http://www.sdge.com/business/street-lighting/understanding-your-street-lighting-rates

As seen in Table C-16, the percentage of efficient lamps has increased from the previous study for PG&E and SDG&E whereas SCE remains the same in its distribution of baseline lamps and efficient lamps. This table represents both customer and IOU owned lamps.

Table C-16: Percentage of Baseline and Efficient Street Lamps by Utility

Year	Efficient Lamps (%)			Baseline lamps (%)		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
2013	4%	1%	23%	96%	99%	77%
2015	26%	1%	31%	74%	99%	69%

Source: Navigant team analysis of IOU-provided lamp inventories (2015)

As shown in Table C-17, the majority of lamps for PG&E and SDG&E are owned by customers, and that has not changed significantly since the last update. There is a slight increase in customer owned lamps for PG&E and a similar decrease for SCE. The majority of SCE lamps are utility owned. Navigant's analysis of secondary sources for SDG&E maintained a consistent distribution across years.

Table C-17: Percentage of Customer Owned and Utility Owned Street Lamps

Year	Customer Owned (%)			Utility Owned (%)		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
2013	74%	17%	81%	26%	83%	19%
2015	76%	15%	81%	24%	85%	19%

Source: Navigant team analysis of IOU-provided lamp inventories (2015)

Subsector Consumption Data: Quarterly Fuel and Energy Report (QFER)

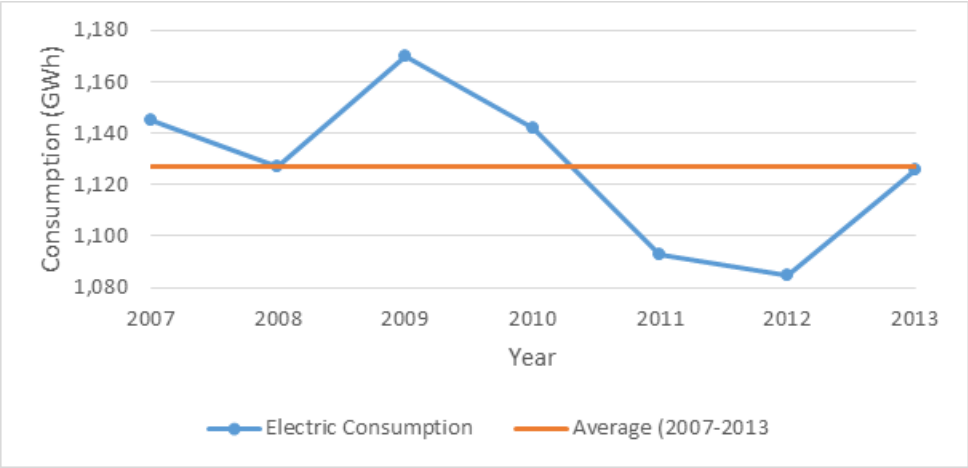
Navigant obtained updated QFER data from the CEC to support the Stage 1 updates.[107] For the Street Lighting sector inputs, Navigant relies on the total QFER data to vet the sector-wide roll up of consumption developed as part of the bottoms-up analysis approach. New electric consumption data for 2013 (the most recent year available from QFER) has been incorporated into the inputs to inform the estimate of equipment distributions of street, sign, and traffic lighting. The IOU consumption data for street lighting along with the QFER data (that represents all streets, signs, and traffic lighting) allow Navigant to parse out consumption for traffic and sign lighting.

As see in Figure C-7, the consumption data for the street lighting subsector varies. Consumption increased from 2007 to 2009, decreases from 2009 and 2012, and increases slightly in 2013. A portion of the decrease can be attributed to LED adoption, but Navigant is unable to account for all trends. Additionally, the data trend does not appear to align with IOU lamp inventory changes or growth trends (e.g., suburban sprawl). Navigant has therefore normalized the data by taking a seven year average (2007-2013) in order to mitigate the fluctuation. In turn, this average mitigates the year-over-year

[107] Ibid, QFER.

fluctuation seen in the distribution of consumption across the three subsectors: street, sign, and traffic lights.

Figure C-7: Street Lighting Sector Electric Consumption (GWh)[108]



LED Costs – Department of Energy Data

Navigant updated the cost data from the 2013 Study for LED lamps. Navigant relied on the DOE study[109] which provides a comprehensive forecast of costs and efficacies of solid-state street lighting to update the cost for LED lamps. The DOE report informed inputs in terms of normalized cost ($/klumen) and efficacy (lumens/watt). An average LED wattage of 71W from the lamp data provided by the IOUs was combined with these DOE parameters to calculate the cost per lamp for LEDs. The improvement of efficacy and reduction of LED costs in general resulted in a 22 percent decrease in LED costs from the 2013 Study. See the Emerging Technology report section for more details on how this DOE study also informed ET vectors for LEDs.

[108] Ibid, QFER data.
[109] Ibid, DOE Solid-State Lighting.

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Appendix D. Codes & Standards

Table D-1: C&S Vectors

Measure Name	Sector	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Ag HVAC - Equipment (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag HVAC - Equipment (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Motor Pmp - Equipment (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Motor Pmp - Equipment (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Motor Pmp - Equipment (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Motor Pmp - O&M (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Motor Pmp - O&M (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Motor Pmp - O&M (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Dry - Equipment (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Dry - Equipment (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Dry - Equipment (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Dry - O&M (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Dry - O&M (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Dry - O&M (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Mtr - Equipment (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Mtr - Equipment (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Mtr - Equipment (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Mtr - O&M (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Mtr - O&M (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Process Mtr - O&M (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Ag Refrigeration - Equipment (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Refrigeration - Equipment (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Refrigeration - Equipment (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Refrigeration - O&M (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Refrigeration - O&M (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag Refrigeration - O&M (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag SHWC - Equipment (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag SHWC - Equipment (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag SHWC - Equipment (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag SHWC - O&M (High Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag SHWC - O&M (Low Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ag SHWC - O&M (Mid Cost)	Agricultural	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Clothes Washer (Electric)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
AppPlug - Clothes Washer (Electric) - Emerging	Residential	100%	100%	100%	79%	79%	79%	79%	79%	79%	79%
AppPlug - Clothes Washer (Gas)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
AppPlug - Clothes Washer (Gas) - Emerging	Residential	100%	100%	100%	79%	79%	79%	79%	79%	79%	79%
AppPlug - Computer Monitor	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Computer Monitor	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Desktop Computer (Com - Power Management)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Desktop Computer (Res - ES Plus)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Desktop Computer (Res - ES)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Dishwasher (Electric)	Residential	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
AppPlug - Dishwasher (Electric) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Dishwasher (Gas)	Residential	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
AppPlug - Dishwasher (Gas) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

AppPlug - HP Clothes Dryer - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Occupancy Sensor Plug Strip	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Recycle Refrigerator	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Self-Contained Refrigerator	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Self-Contained Refrigerator - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Smart Strip Home Office - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Smart Strip Home Theater - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Variable Speed Pool Pump	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
AppPlug - Vending Machine Controls	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Attic Batt Insulation	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Attic Batt Insulation	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Wall Spray On Insulation	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Wall Spray On Insulation	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Window Film	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
BldgEnv - Window Film	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Door Gasket (Reach-In Refrigerator)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Door Gasket (Walk-In Refrigerator)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Refrigerated Case Night Cover (Low Temp)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Refrigerated Case Night Cover (Med Temp)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ComRefrig - Strip Curtain for Walk In Refrigerator	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Electric Griddle	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Electric Steamer	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Fryer (Electric)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Fryer (Gas)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Grill to Order Cabinet	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

FoodServ - Oven (Electric)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
FoodServ - Oven (Gas)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Comprehensive Rooftop Unit Quality Maintenance	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Advanced Package Rooftop AC (> EER 12) - Emerging	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - AFUE Rated Boiler (High)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - AFUE Rated Boiler (Standard)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Chiller (Centrifugal)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Chiller (Reciprocating)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Chiller (Screw)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Demand Controlled Ventilation	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Direct Evaporative Cooler	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Direct Evaporative Cooler	Residential	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
HVAC - EER Rated Package Rooftop AC (EER 11)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - EER Rated Package Rooftop HP (EER 11)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Energy Management System	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Energy Recovery Ventilation - Emerging	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - ET Rated Boiler (High)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - ET Rated Boiler (Standard)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Gas Furnace	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Gas Furnace	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Gas Furnace - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Repair Duct System	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Repair Duct System	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Package Rooftop AC (Recharge)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Package Rooftop AC (SEER 14)	Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

HVAC - SEER Rated Package Rooftop AC (SEER 15)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Package Rooftop HP (SEER 14)	Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HVAC - SEER Rated Package Rooftop HP (SEER 15)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System AC (Recharge)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System AC (SEER 14)	Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HVAC - SEER Rated Split System AC (SEER 15)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System AC (SEER 15)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System AC (SEER 18)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System AC (SEER 22) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System HP (SEER 14)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System HP (SEER 15)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System HP (SEER 15)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System HP (SEER 18)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - SEER Rated Split System HP (SEER 21) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
HVAC - Thermostat	Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HVAC - Whole House Fan	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - Equipment (Electric - High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - Equipment (Electric - Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - Equipment (Electric - Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - Equipment (Gas - High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - Equipment (Gas - Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - Equipment (Gas - Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - O&M (Electric - High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - O&M (Electric - Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - O&M (Electric - Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Ind HVAC - O&M (Gas - High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - O&M (Gas - Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind HVAC - O&M (Gas - Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind Lighting - Equipment (High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind Lighting - Equipment (Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind Lighting - Equipment (Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind Lighting - O&M (High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind Lighting - O&M (Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind Lighting - O&M (Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind MachDr - Equipment (High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind MachDr - Equipment (Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind MachDr - Equipment (Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind MachDr - O&M (High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind MachDr - O&M (Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind MachDr - O&M (Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - Equipment (Electric - High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - Equipment (Electric - Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - Equipment (Electric - Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - Equipment (Gas - High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - Equipment (Gas - Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - Equipment (Gas - Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - O&M (Electric - High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - O&M (Electric - Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - O&M (Electric - Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - O&M (Gas - High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Ind ProcHeat - O&M (Gas - Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcHeat - O&M (Gas - Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcRefrig - Equipment (High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcRefrig - Equipment (Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcRefrig - Equipment (Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcRefrig - O&M (High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcRefrig - O&M (Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind ProcRefrig - O&M (Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind SHW - Equipment (High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind SHW - Equipment (Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind SHW - Equipment (Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind SHW - O&M (High Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind SHW - O&M (Low Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ind SHW - O&M (Mid Cost)	Industrial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Cold Cathode Lamp	Commercial	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Fixture (Indoor)	Commercial	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Fixture (Indoor)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Fixture (Outdoor)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Basic High - Indoor)	Commercial	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Basic High - Indoor)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Basic High - Outdoor)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Basic Low - Indoor)	Commercial	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Basic Low - Indoor)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Basic Low - Outdoor)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Compact Fluorescent Lamp (Reflector - Indoor)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Lighting - Compact Fluorescent Lamp (Reflector - Outdoor)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Compact Fluorescent Lamp (Specialty - Indoor)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Compact Fluorescent Lamp (Specialty - Outdoor)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Exit Fixture (LED)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Halogen Lamp (A-Line)	Commercial	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Halogen Lamp (A-Line)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Halogen Lamp (Reflector)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Halogen Lamp (Reflector)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - High Bay HID to T5	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Induction Fixture (Indoor)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Induction Fixture (Outdoor)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Induction Fixture (Outdoor)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Fixture (Replacing T8) - Emerging	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Lamp (Basic High - Indoor) - Emerging	Commercial	100%	100%	100%	13%	13%	13%	13%	13%	13%	13%
Lighting - LED Lamp (Basic High - Indoor) - Emerging	Residential	100%	100%	100%	21%	21%	21%	21%	21%	21%	21%
Lighting - LED Lamp (Basic High - Outdoor) - Emerging	Residential	100%	100%	100%	17%	17%	17%	17%	17%	17%	17%
Lighting - LED Lamp (Basic Low - Indoor) - Emerging	Commercial	100%	100%	100%	15%	15%	15%	15%	15%	15%	15%
Lighting - LED Lamp (Basic Low - Indoor) - Emerging	Residential	100%	100%	100%	18%	18%	18%	18%	18%	18%	18%
Lighting - LED Lamp (Basic Low - Outdoor) - Emerging	Residential	100%	100%	100%	17%	17%	17%	17%	17%	17%	17%
Lighting - LED Lamp (Reflector - Indoor) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Lamp (Reflector - Outdoor) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Lamp (Specialty - Indoor) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Lamp (Specialty - Outdoor) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - LED Plug-In Indoor Fixture - Emerging	Commercial	100%	100%	100%	6%	6%	6%	6%	6%	6%	6%
Lighting - LED Plug-In Indoor Fixture - Emerging	Residential	100%	100%	100%	7%	7%	7%	7%	7%	7%	7%

Lighting - LED Plug-In Outdoor Fixture - Emerging	Residential	100%	100%	100%	5%	5%	5%	5%	5%	5%	5%
Lighting - Light Sensor	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Linear Fluorescent Delamping	Commercial	75%	50%	25%	0%	0%	0%	0%	0%	0%	0%
Lighting - Linear Fluorescent Delamping	Residential	75%	50%	25%	0%	0%	0%	0%	0%	0%	0%
Lighting - Linear Fluorescent Fixture (Low Wattage T8)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Linear Fluorescent Fixture (T8)	Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Lighting - Low Bay HID to T5	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Night Light Fixture (LED)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Occupancy Sensor	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Occupancy Sensor	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (Compact Fluorescent)	Commercial	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Plug-In Fixture (Exterior)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (Exterior)	Residential	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Plug-In Fixture (Induction)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (Linear Fluorescent)	Commercial	100%	100%	100%	0%	0%	0%	0%	0%	0%	0%
Lighting - Plug-In Fixture (Linear Fluorescent)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (MH Directional)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (PSMH with Electronic Ballast)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Plug-In Fixture (PSMH)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Lighting - Seasonal Lighting	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Oil - Pump Controls	Mining	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Oil - Pump Motor	Mining	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Oil - Pump Motor and Controls	Mining	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Oil - Steam Boiler	Mining	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Oil - Steam Boiler Controls and Improvements	Mining	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

ProcHeat - Boiler Controls	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
ProcHeat - Boiler Draft Fan	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Service - HVAC Fault Detection & Diagnositics	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Service - Retro-Commissioning (Electric)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Service - Retro-Commissioning (Gas)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Heat Pump Water Heater	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Instantaneous Water Heater (Electric)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Instantaneous Water Heater (Electric)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Instantaneous Water Heater (Gas)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Instantaneous Water Heater (Gas)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Storage Water Heater (Electric)	Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SHW - EF Rated Storage Water Heater (Electric)	Residential	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SHW - EF Rated Storage Water Heater (Gas)	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Storage Water Heater (Gas)	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Storage Water Heater (Gas) - Emerging	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - EF Rated Storage Water Heater (Gas) - Emerging	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - ET Rated Instantaneous Water Heater	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - ET Rated Storage Water Heater	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - ET Rated Storage Water Heater - Emerging	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SHW - Pipe and Tank Insulation	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
StreetLight - Base with Controls	Street Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
StreetLight - Induction	Street Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
StreetLight - Induction with Controls	Street Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
StreetLight - LED	Street Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
StreetLight - LED with Controls	Street Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

WholeBlg - Com NC Level 1	Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
WholeBlg - Com NC Level 2	Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
WholeBlg - Com NC Level 3	Commercial	18%	18%	5%	5%	5%	0%	0%	0%	0%	0%
WholeBlg - Com NC ZNE	Commercial	62%	62%	50%	50%	50%	37%	37%	37%	25%	25%
WholeBlg - Com RET Level 1	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
WholeBlg - Com RET Level 2	Commercial	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
WholeBlg - Low Income	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
WholeBlg - Res NC Level 1	Residential	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
WholeBlg - Res NC Level 2	Residential	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
WholeBlg - Res NC Level 3	Residential	17%	17%	0%	0%	0%	0%	0%	0%	0%	0%
WholeBlg - Res NC ZNE	Residential	100%	100%	62%	62%	62%	38%	38%	38%	38%	38%
WholeBlg - Res RET Energy Upgrade CA - Advanced Path	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
WholeBlg - Res RET Energy Upgrade CA - Basic Path	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
WholeBlg - Res RET Energy Upgrade CA - Flex Path	Residential	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table D-2: C&S Measures

Regulation	Code or Standard Name	Compliance Rate	Effective Date	Policy View
2005 T-20	Commercial Refrigeration Equipment, Solid Door	70%	1/1/2006	On the books
2005 T-20	Commercial Refrigeration Equipment, Transparent Door	70%	1/1/2007	On the books
2005 T-20	Commercial Ice Maker Equipment	70%	1/1/2008	On the books
2005 T-20	Walk-In Refrigerators / Freezers	91%	1/1/2006	On the books
2005 T-20	Commercial Refrigeration Equipment, Solid Door	70%	1/1/2006	On the books
2005 T-20	Refrigerated Beverage Vending Machines	37%	1/1/2006	On the books
2005 T-20	Large Packaged Commercial Air-Conditioners, Tier 1	70%	10/1/2006	On the books
2005 T-20	Large Packaged Commercial Air-Conditioners, Tier 2	70%	1/1/2010	On the books
2005 T-20	Residential Pool Pumps, High Eff Motor, Tier 1	100%	1/1/2006	On the books
2005 T-20	Portable Electric Spas	70%	1/1/2006	On the books
2005 T-20	General Service Incandescent Lamps, Tier 1	69%	1/1/2006	On the books
2005 T-20	Pulse Start Metal Halide HID Luminaires, Tier 1(Vertical Lamps)	100%	1/1/2006	On the books
2005 T-20	Pulse Start Metal Halide HID Luminaires, Tier 2 (All other MH)	100%	1/1/2008	On the books
2005 T-20	Modular Furniture Task Lighting Fixtures	70%	1/1/2008	On the books
2005 T-20	Hot Food Holding Cabinets	70%	1/1/2006	On the books
2005 T-20	External Power Supplies, Tier 1	100%	1/1/2007	On the books
2005 T-20	External Power Supplies, Tier 2	99%	7/1/2008	On the books
2005 T-20	Consumer Electronics - Audio Players	100%	1/1/2007	On the books
2005 T-20	Consumer Electronics - TVs	96%	1/1/2006	On the books
2005 T-20	Consumer Electronics - DVDs	31%	1/1/2006	On the books
2005 T-20	Water Dispensers	70%	1/1/2006	On the books
2005 T-20	Unit Heaters and Duct Furnaces	100%	1/1/2006	On the books

2005 T-20	Commercial Dishwasher Pre-Rinse Spray Valves	100%	1/1/2006	On the books
2006 T-20	Residential Pool Pumps, 2-speed Motors, Tier 2	86%	1/1/2008	On the books
2006 T-20	General Service Incandescent Lamps, Tier 2	87%	1/1/2008	On the books
2006 T-20	General Service Incandescent Lamps, Tier 2	87%	1/1/2008	On the books
2006 T-20	General Service Incandescent Lamps, Tier 2	89%	1/1/2008	On the books
2006 T-20	BR, ER and R20 Incandescent Reflector Lamps: Residential	82%	1/8/2008	On the books
2006 T-20	BR, ER and R20 Incandescent Reflector Lamps: Commercial	82%	1/8/2008	On the books
2008 T-20	Metal Halide Fixtures	95%	1/1/2010	On the books
2008 T-20	Portable Lighting Fixtures	93%	1/1/2010	On the books
2008 T-20	General Purpose Lighting -- 100 watt	88%	1/1/2011	On the books
2008 T-20	General Purpose Lighting -- 75 watt	40%	1/1/2012	On the books
2008 T-20	General Purpose Lighting -- 60 and 40 watt	85%	1/1/2013	On the books
2009 T-20	Televisions - Tier 1	98%	1/1/2011	On the books
2009 T-20	Televisions - Tier 2	85%	1/1/2013	On the books
2011 T-20	Battery charger - consumer - Tier 1	85%	2/1/2013	On the books
2011 T-20	Battery charger - large - Tier 1	85%	1/1/2014	On the books
2011 T-20	Battery charger - large - Tier 2 incremental	85%	1/1/2014	On the books
Future Title 20	Air Filter Labeling	85%	1/1/2016	Expected
Future Title 20	Commercial Clothes Dryers	85%	1/1/2016	Expected
Future Title 20	Computers - Tier 1 | Desktops, Notebooks	85%	6/1/2016	Expected
Future Title 20	Dimming Ballasts	85%	1/1/2016	Expected
Future Title 20	Electronic Displays	85%	1/1/2016	Expected
Future Title 20	Faucets (Residential)- Gas Water Heaters	85%	1/1/2016	Expected
Future Title 20	Faucets (Residential)- Electric Water Heaters	85%	1/1/2016	Expected
Future Title 20	Game Consoles (Tier 1)	85%	1/1/2016	Expected

Future Title 20	Game Consoles (Tier 2)	85%	1/1/2019	Expected
Future Title 20	Pool Pumps & Spas	85%	1/1/2016	Expected
Future Title 20	Set Top Boxes (Tier 1)	85%	1/1/2016	Expected
Future Title 20	Small Diameter Directional Lamps (Tier 1)	85%	1/1/2016	Expected
Future Title 20	Small Diameter Directional Lamps (Tier 2)	85%	1/1/2016	Expected
Future Title 20	Small Network Equipment	85%	1/1/2016	Expected
Future Title 20	Toilets (Commercial)	85%	1/1/2016	Expected
Future Title 20	Toilets (Residential)	85%	1/1/2016	Expected
Future Title 20	Urinals	85%	1/1/2016	Expected
Future Title 20	Water Meters	85%	1/1/2016	Expected
Federal	Electric Motors 1-200HP	91%	12/1/2010	On the books
Federal	Refrigerated Beverage Vending Machines	37%	8/31/2011	On the books
Federal	Commercial Refrigeration	70%	1/1/2012	On the books
Federal	Residential Electric & Gas Ranges	100%	4/9/2012	On the books
Federal	General Service Fluorescent Lamps	95%	7/14/2012	On the books
Federal	Incandescent Reflector Lamps	7%	7/14/2012	On the books
Federal	Commercial Clothes Washers	95%	1/8/2013	On the books
Federal	Residential Pool Heaters	95%	4/16/2013	On the books
Federal	Residential Direct Heating Equipment	95%	4/16/2013	On the books
Federal	Residential Refrigerators & Freezers	95%	9/15/2014	On the books
Federal	Residential Room AC	95%	6/1/2014	On the books
Federal	Fluorescent Ballasts	95%	11/14/2014	On the books
Federal	Residential Clothes Dryers	95%	1/1/2015	On the books
Federal	Residential Gas Fired Water Heaters	95%	4/16/2015	On the books
Federal	Residential Electric Storage Water Heaters	95%	4/16/2015	On the books

Federal	Residential Gas Instant Water Heaters	95%	4/16/2015	On the books
Federal	Residential Oil Fired Water Heaters	95%	4/16/2015	On the books
Federal	Small Electric Motors	95%	3/9/2015	On the books
Federal	Residential Clothes Washers (Front Loading)	95%	3/7/2015	On the books
Federal	Residential Clothes Washers (Top Loading) Tier I	95%	3/7/2015	On the books
Federal	Residential Clothes Washers (Top Loading) Tier II	95%	1/1/2018	On the books
Federal	Residential Central AC and Heat Pumps	95%	1/1/2015	On the books
Federal	External Power Supplies	95%	2/10/2016	On the books
Federal	Battery Chargers	95%	3/1/2015	Possible
Federal	Walk-in Coolers & Freezers	95%	6/5/2017	On the books
Federal	Distribution Transformers	95%	6/1/2016	On the books
Federal	Commercial Refrigeration (Cycle 2)	95%	3/27/2017	On the books
Federal	Metal Halide Lamp Fixtures	95%	2/10/2017	On the books
Federal	High-Intensity Discharge Lamps	95%	6/1/2017	Possible
Federal	General Service Fluorescent Lamps	95%	1/26/2018	On the books
Federal	ASHRAE Products (Commercial boilers)	95%	3/2/2012	On the books
2005 T-24	Time dependent valuation, Residential	0%	1/1/2006	On the books
2005 T-24	Time dependent valuation, Nonresidential	0%	1/1/2006	On the books
2005 T-24	Res. Hardwired lighting	113%	1/1/2006	On the books
2005 T-24	Duct improvement	59%	1/1/2006	On the books
2005 T-24	Window replacement	80%	1/1/2006	On the books
2005 T-24	Lighting controls under skylights	8%	1/1/2006	On the books
2005 T-24	Ducts in existing commercial buildings	75%	1/1/2006	On the books
2005 T-24	Cool roofs	75%	1/1/2006	On the books
2005 T-24	Relocatable classrooms	100%	1/1/2006	On the books

2005 T-24	Bi-level lighting control credits	79%	1/1/2006	On the books
2005 T-24	Duct testing/sealing in new commercial buildings	82%	1/1/2006	On the books
2005 T-24	Cooling tower applications	88%	1/1/2006	On the books
2005 T-24	Multifamily Water Heating	78%	1/1/2006	On the books
2005 T-24	Composite for Remainder - Res	120%	1/1/2006	On the books
2005 T-24	Composite for Remainder - Non-Res	85%	1/1/2006	On the books
2005 T-24	Whole Building - Res New Construction (Electric)	120%	1/1/2006	On the books
2005 T-24	Whole Building - Non-Res New Construction (Electric)	0%	1/1/2006	On the books
2005 T-24	Whole Building - Res New Construction (Gas)	235%	1/1/2006	On the books
2005 T-24	Whole Building - Non-Res New Construction (Gas)	0%	1/1/2006	On the books
2008 T-24	Envelope insulation	86%	10/1/2010	On the books
2008 T-24	Overall Envelope Tradeoff	141%	10/1/2010	On the books
2008 T-24	Skylighting	141%	10/1/2010	On the books
2008 T-24	Sidelighting	141%	10/1/2010	On the books
2008 T-24	Tailored Indoor lighting	462%	10/1/2010	On the books
2008 T-24	TDV Lighting Controls	0%	10/1/2010	On the books
2008 T-24	DR Indoor Lighting	0%	10/1/2010	On the books
2008 T-24	Outdoor Lighting	0%	10/1/2010	On the books
2008 T-24	Outdoor Signs	83%	10/1/2010	On the books
2008 T-24	Refrigerated warehouses	83%	10/1/2010	On the books
2008 T-24	DDC to Zone	141%	10/1/2010	On the books
2008 T-24	Residential Swimming pool	0%	7/1/2010	On the books
2008 T-24	Site Built Fenestration	83%	10/1/2010	On the books
2008 T-24	Residential Fenestration	83%	7/1/2010	On the books
2008 T-24	Cool Roof Expansion	400%	10/1/2010	On the books

2008 T-24	MF Water heating control	141%	9/1/2010	On the books
2008 T-24	CfR IL Complete Building Method	459%	9/1/2010	On the books
2008 T-24	CfR IL Area Category Method	456%	9/1/2010	On the books
2008 T-24	CfR IL Egress Control	141%	9/1/2010	On the books
2008 T-24	CfR HVAC Efficiency	141%	9/1/2010	On the books
2008 T-24	CfR Res Cool Roofs	83%	9/1/2010	On the books
2008 T-24	CfR Res Central Fan WL	83%	9/1/2010	On the books
2013 T-24	2013 T-24 - Single family NC	83%	7/1/2014	On the books
2013 T-24	2013 T-24 - Multi-family NC	83%	9/1/2014	On the books
2013 T-24	2013 T-24 - Nonres NC	83%	10/1/2014	On the books
2013 T-24	2013 T-24 - others	70%	9/1/2014	On the books
2016 T-24	2016 T-24 - Single family NC	83%	7/1/2017	Expected
2016 T-24	2016 T-24 - Multi-family NC	83%	9/1/2017	Expected
2016 T-24	2016 T-24 - Nonres NC	83%	10/1/2017	Expected
2019 T-24	2019 T-24 - Single family NC	83%	7/1/2020	Possible
2019 T-24	2019 T-24 - Multi-family NC	83%	9/1/2020	Possible
2019 T-24	2019 T-24 - Nonres NC	83%	10/1/2020	Possible
2022 T-24	2022 T-24 - Single family NC	83%	7/1/2023	Possible
2022 T-24	2022 T-24 - Multi-family NC	83%	9/1/2023	Possible
2022 T-24	2022 T-24 - Nonres NC	83%	10/1/2023	Possible

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Appendix E. Behavior Analysis Data Sources

The team reviewed close to a dozen sources to inform the non- residential behavior updates. The key sources are listed below.

- Cadmus Group Inc., Focus on Energy MEEA Training Program Evaluation, January 2015, Public Service Commission of Wisconsin
- Opinion Dynamics Corporation, Impact Evaluation Of The California Statewide Building Operator Certification Program, February 2014, California Public Utilities Commission
- Research Into Action, BOC-Expansion Initiative Market Progress Evaluation Report #1, April 2014 , Northwest Energy Efficiency Alliance
- Navigant Consulting Inc., Opinion Dynamics Corporation, and Itron, Program Year 3 DCEO Building Operator Certification (BOC) Program Evaluation, May 2012, Illinois Department of Commerce and Economic Opportunity
- Research Into Action and Energy Market Innovations (EMI), Summary Of Building Operator Certification Program Evaluations, November 2011, Consumers Energy
- Navigant Consulting, Inc., Long Term Monitoring and Tracking Report on 2011 Activities , July 2012, Northwest Energy Efficiency Alliance
- Navigant Consulting, Inc., Evaluation Of MN BOC Training, March 2011, Midwest Energy Efficiency Alliance and Minnesota Office of Energy Security
- Navigant Consulting, Inc., Long Term Monitoring and Tracking Report on 2010 Activities, June 2011, Northwest Energy Efficiency Alliance
- Navigant Consulting, Inc., Long Term Monitoring and Tracking Report on 2009 Activities, October 2010, Northwest Energy Efficiency Alliance
- Opinion Dynamics Corporation, Evaluation Of Kansas City Power and Light's Building Operator Certification Program, September 2009, Kansas City Power and Light
- RLW Analytics, Impact and Process Evaluation Building Operator Training and Certification (BOC) Program, September 2005, Northeast Energy Efficiency Partnerships

The team reviewed over 50 sources to inform the residential behavior updates. The key sources are listed below.

- 2012 IPL Residential Peer Comparison EM&V Report July 11, 2013. Maria Larson. TecMarket Works, Opinion Dynamics, The Cadmus Group, Integral Analytics and Building Metrics. 2013.
- 2013 Home Energy Report Evaluation. Bobette Wilhelm. DNV GL. 2014.
- 2013 PG&E Home Energy Reports Program . n/a. DNV-GL. 2015.
- 2013 PG&E Home Energy Reports Program . n/a. NEXANT. 2015.

» 2013 SCE Home Energy Reports Program. n/a. DNV-GL. 2014.

» 2013 SDG&E Home Energy Reports Program . n/a. DNV-GL. 2014.

» Analysis of PSEs Pilot Energy Conservation Project: Home Energy Reports (2011). . LBNL. .

» C3-CUB Energy Saver Program EPY5 Evaluation Report. Bill Provencher, Carly McClure. Navigant. 2014.

» CPUC. SW EA Monthly Metrics Report All IOUs Oct 2014_111314.xlsx. January 2014

» CPUC. Email from Valerie Richardson. February 2014

» Energy Efficiency / Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010). Bill Provencher. Navigant.

» Energy Efficiency / Demand Response Plan: Plan Year 3 (6/1/2010-5/31/2011). Bethany Glinsman, Bill Provencher. Navigant.

» Energy Efficiency Nicor Gas Plan Year 1, Evaluation Report: Behavioral Energy Savings Pilot. Jenny Hampton. Navigant. 2013.

» Energy Efficiency/Demand Response Plan Year 3, 2011 Evaluation Report HER Program. Randy Gunn, Stu Slote, Bill Provencher, Bethany Glinsmann, Paul Wozniak. Navigant. 2012.

» Energy Efficiency/Demand Response Plan Year 4, Evaluation Report: Home Energy Reports. Randy Gunn, Bill Provencher, Bethany Glinsmann. Navigant. 2012.

» Energy Efficiency/Demand Response Plan Year 5, Evaluation Report: Home Energy Reports. Bill Provencher, Bethany Glinsmann. Navigant. 2014.

» Energy Efficiency/Demand Response Plan: Plan Year 4 (6/1/2011---5/31/2012). Bethany Glinsman, Bill Provencher. Navigant.

» Evaluation of 2013 DSM Portfolio. Adam Thomas, Steven Keates, P.E., Jeremey Offenstein, Ph.D., Julianna Mandler, Zephaniah Davis, Jay Blatchford, Don Dohrmann, Ph.D. ADM Associates, Inc. 2014.

» Evaluation of PG&E's Home Energy Report Initiative for the 2010-2012 Program. Michael Perry, Sarah Woehleke. Freeman, Sullivan & Co. 2013.

» Evaluation of Residential Incentive Program Portfolio (May - Dec 2012). . ADM Associates. .

» Evaluation of the Home Energy Report Program. Bethany Glinsmann, Bill Provencher. Navigant. 2012.

» Evaluation of the Year 2 CL&P Pilot Customer Behavior Program (R2). NMR Group, Inc. Tetra Tech, Oversight Evaluation Contractor:, Lisa Skumatz, Skumatz Economic Research Associates, Scott Dimetrosky, Apex Analytics, Lori Lewis, AEC. NMR Group, Tetra Tech, Skumatz, Apex. 2014.

» Evaluation of Year 1 of the CL&P Pilot Customer Behavior Program (Draft) . Hunt Allcott. NMR Group, Tetra Tech, Hunt Allcott. 2013.

» Evaluation Report: OPOWER SMUD Pilot Year2. Bill Provencher. Navigant.

» Home Energy Report Program. Sharon Noell. DNV GL. 2014.

» Home Energy Reports Program, Program Year 2012 Evaluation Report. Navigant. 2013.

» Home Energy Savings Program GPY2/EPY5 Evaluation Report, Nicor Gas. Miroslav Lysyuk, Ryan Powanda, Mark Thornsjo. Navigant. 2014.

» Impact & Persistence Evaluation Report Sacramento Municipal Utility District Home Energy Report Program. Mary Wu (Pete Jacobs and Patricia Thompson contributed). Integral Analytics. 2012.

» Impact and Process Evaluation Of 2011 (Py4) Ameren Illinois Company Behavioral Modification Program (Oct 2012). Olivia Patterson, Jeevika Galhotra. ODC/Navigant. 2012.

» Impact and Process Evaluation of 2011 (Py5) Ameren Illinois Company Behavioral Modification Program (Oct 2012). Olivia Patterson, Jeevika Galhotra. ODC/Navigant. 2014.

» Impact and Process Evaluation of 2011 (Py6) Ameren Illinois Company Behavioral Modification Program (Oct 2012). Olivia Patterson, Jeevika Galhotra. ODC/Navigant. 2015.

» Massachusetts Cross Cutting Evaluation Home Energy Report Savings Decay Analysis. Hannah Arnold, Olivia Patterson, Katherine Randazzo, Amanda Dwelley. Opinion Dynamics. 2014.

» Massachusetts Cross-Cutting Behavioral Program Evaluation Integrated Report June 2013. Anne Dougherty. ODC/Navigant . 2013.

» MASSACHUSETTS CROSS-CUTTING BEHAVIORAL PROGRAM EVALUATION Volume II Final (June 2011). Anne Dougherty. ODC/Navigant. 2011.

» MASSACHUSETTS CROSS-CUTTING BEHAVIORAL PROGRAM EVALUATION Volume I Final (June 2011). Anne Dougherty. ODC/Navigant. 2011.

» Massachusetts Three Year Cross-Cutting Behavioral Program Evaluation Integrated Report July 2012. Anne Dougherty. ODC/Navigant . 2012.

» Measurement and Verification Report of Lake Country's Opower Energy Efficiency Pilot Program. . Power System Engineering. 2010.

» Measurement and Verification Report of OPower Energy Efficiency Pilot Program. . Power System Engineering. 2010.

» National Grid Residential Building Practices and Demonstration Program Evaluation Final Results. n/a. DNV KEMA . 2014.

» New Jersey Market Assessment, Opportunities for Energy Efficiency. EnerNOC. 2013.

» Nexant, Evaluation of Southern California Gas Company's 2013-2014 Conservation Campaign Submitted to Southern California Gas Company, August 29, 2014.

» PECO Act 129 – Phase II Research Report: Program Year 5. Jenny Hampton . Navigant. 2013.

» Process Evaluation Report, EE&C Plan, Program Year Four. Anne West, Hope Lobkowicz. The Cadmus Group Inc.. 2013.

- Puget Sound Energy's Home Energy Reports 2012 Impact Evaluation (Mar 2013). n/a. KEMA. 2013.
- Puget Sound Energy's Home Energy Reports Program Three Year Impact, Behavioral and Process Evaluation (2012). n/a. KEMA. 2012.
- Puget Sound Energy's Home Energy Reports Program: 20 Month Impact Evaluation. n/a. KEMA. 2010.
- PWP Home Energy Report (HER) Evaluation Results, Memo. Bethany Glinsmann, Bill Provencher. Navigant. 2013.
- PY1 EM&V Report for the Residential Energy Efficiency Benchmarking Program. Stuart Schare, Bethany Glinsman, Jenny Hampton, Robert Russell. Navigant. 2012.
- PY2 EM&V Report for the Residential Energy Efficiency Benchmarking Program. Stuart Schare, Bethany Glinsman, Jenny Hampton, Ming Xie, Amy Meyer. Navigant. 2014.
- Readying Michigan to Make Good Energy Decisions: Energy Efficiency. Michigan Economic Development Corporation / GDS Associates. 2013.
- Review of PG&E Home Energy Reports Initiative Evaluation (2013). n/a. KEMA. 2013.
- SCE's Home Energy Report Program Savings Assessment. Patric Ignelzi. Applied Energy Group. 2014.
- SDG&E Home Energy Reports Program Savings Results. n/a. KEMA. 2013.
- Smart Energy Manager Program 2013 Evaluation Report. Bethany Glinsmann, Bill Provencher, Brent Barkett. Navigant. 2014.
- Summit Blue Evaluation Report - SMUD. Bill Provencher . Navigant.
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- Utah Home Energy Reporting Program. Bill Provencher, Bethany Glinsmann, Argene McDowell, Amanda Bond, Dave Basak. Navigant. 2014.
- Verification of Hawaii Energy 2011 Programs. n/a. Evergreen Economics. 2012.
- Washington Home Energy Reporting Program 18 month evaluation report. Bill Provencher, Bethany Glinsmann, Argene McDowell, Amanda Bond, Dave Basak. Navigant. 2014.